THE MONTHLY

Review

Ah..h..h.. The Time's Nearer

For Details About

The Hall Of Platers' Contribution To The WAR Effort

Official Organ of the American Electroplaters' Society
A Society for the Advancement of the Science of Electroplating

NOVEMBER ✦ ✦ ✦ 1945

Amazing New Development

CLEPO MOL-EX PROCESS

(MOLECULAR EXPLOSION)

for

SIMPLIFIED FAST BUFFING COMPOUND REMOVAL PRIOR TO BRIGHT NICKEL AND OTHER PLATING SOLUTIONS

Operates on principle of MOLECULAR EXPLOSIONS based on macroscopic bombardment action which keeps solutions moderately aggitated. Lustre of base metal maintained throughout.

Send for special booklet describing MOL-EX process, if you are planning a BRIGHT NICKEL plating cycle or any cycle where it is necessary to remove buffing compounds.

If you are ready to start production now, send for CLEPO service man to immediately install the CLEPO MOL-EX PROCESS at your plant.

FREDERICK GUMM *Chemical Company Inc.*

538 FOREST STREET, KEARNY, N. J.

RECONVERSION
puts the eye
ON COSTS

War production's cry was speed and *more* speed! Today's peacetime competition calls for speed *plus* low cost of production.

In reconverting your die casting economy you'll want to check the speed and savings that go with Oakite Surface Preparation.

from Aluminum to Zinc . . .

. . . there are specialized Oakite cleaning methods for each die cast metal, methods that insure physically and chemically clean die casting surfaces thoroughly prepared to take a perfect finish . . . methods that give you the *best* in production cleaning even while cutting corners on time and cost.

● *A free digest,* "PRODUCTION CLEANING OF DIE CASTINGS" *will be sent on request.*

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OAKITE MATERIALS · METHODS · SERVICE

Keep Buying Bonds

CLEANING FOR EVERY CLEANING REQUIREMENT

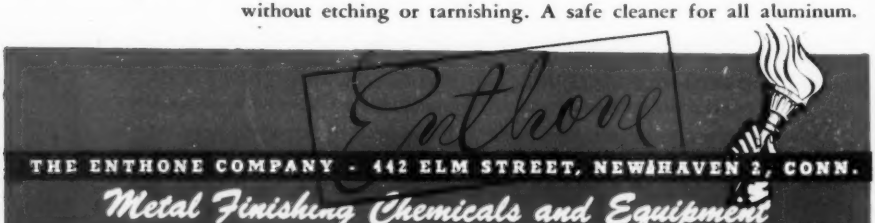
NEW PRODUCTS *for finishing* ALUMINUM

ALUMOX A process for passivating aluminum alloys to resist salt spray and to form a base for organic finishing. The Alumox finish itself is a pleasing grey-green.

ALUMON A process for electroplating upon aluminum. By means of the Alumon dip, aluminum alloys can be prepared for copper, silver, or cadmium plating.

CLEANER-E An etching type aluminum cleaner that gives a fine, beautiful controlled etch finish. An ideal cleaner for preparing aluminum for painting, plating or anodizing.

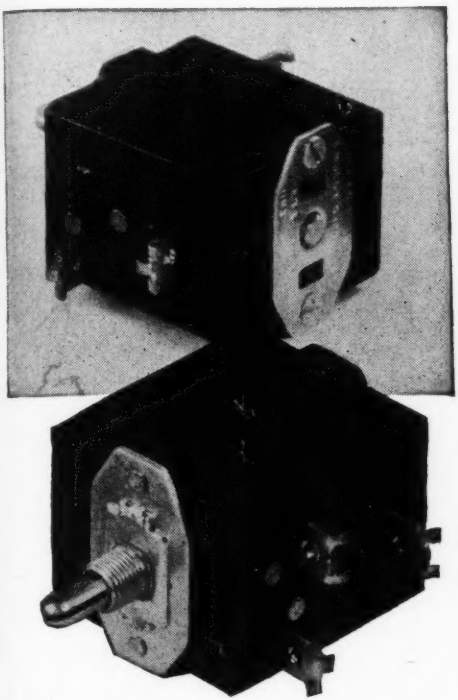
CLEANER-NE A non-etching type alkali aluminum cleaner for degreasing buffed or bright aluminum alloys without etching or tarnishing. A safe cleaner for all aluminum.



CUSTOMERS SEE DOUBLE VALUE

IN

*Luster-on** *Brilliance*



When electrical or radio parts are bright and stain-free they add immeasurably to the appearance value of the finished product. You can achieve this lasting tarnish resistant finish on inexpensive zinc-plated parts by using the low-cost, easily-applied Luster-on* treatment.

Two simple cold dips bring Luster-on* brilliance and a passive surface which resists fingermarks, white corrosion and age stains. Luster-on* on zinc gives all the advantages of cadmium at a fraction of cadmium's cost.

Luster-on* is in no sense a substitute — but rather a new and better product (patent applied for) designed to give surface protection and bright appearance at minimum cost. It is applied without fire hazard or impairing electrical conductivity. Your competitor may be testing Luster-on* right now! How about you?

KEMO SAYS: Sorry we can't send samples of Luster-on*, but we will process and return pieces of work sent to us.

*Patent applied for

THE *Chemical* CORPORATION
54 Waltham Ave., Springfield 9, Mass.

THE CHEMICAL CORPORATION
54 Waltham Ave., Springfield 9, Mass.

Please send me full particulars about Luster-on* bright dip for zinc surfaces. I am (am not) sending sample part for free dip. No obligation, of course.

Name.....

Address.....

The Monthly Review, November 1945

MATERIALS AND METHODS
Equipment
Supplies
EXTRA
MATERIALS AND METHODS
DETROIT, AUGUST, 1945
EXTRA
Number 1
Volume 1
STEVENS COMPOSITIONS PREFERRED
ALUMINUM COOKING UTENSIL MANUFACTURER
ORDERS TWO CARLOADS FOR GENERAL USE
In July of this year, a well known eastern manufacturer of aluminum cooking utensils, reverting to peace time production, placed trial orders for buffing, polishing and coloring compositions with Stevens of Detroit.
Stevens No. 12 Tripoli Composition was selected for buffing operations; No. 830 Tallow Stick for polishing; No. 8 Double Duty and No. 903 Coloring Composition for coloring.
Those Stevens Compositions turned out such beautiful products that they immediately placed their order for two carloads of the assorted compositions, and are now using Stevens Compositions exclusively on all their buffing, polishing and coloring operations.
Stevens Greaseless Compositions of which there are several types and grades—are fast becoming preferred products for producing an excellent finish on Stainless Steel, Silver-ware, etc.
If you are doing this type of work, we shall welcome the opportunity of proving what a good job Stevens Greaseless will do for you. Send us a few finished and unfinished pieces together with data on your present operations. We will finish the pieces and furnish complete data on the compositions used, together with our recommendations.
POLISHING LATHES
•
PLATING EQUIPMENT AND SUPPLIES

WANT LONGER LIFE FOR YOUR BUFFS AND WHEELS... FASTER CUTTING ACTION ...IMPROVED FINISH? THESE ARE GOOD REASONS WHY YOU SHOULD USE

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BUFFING COMPOSITIONS • METAL POLISHERS AND ELECTROPLATERS SUPPLIES-EQUIPMENT

THE MONTHLY

Review

VOLUME 32 • NOVEMBER • NUMBER 11

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$.50 per Copy

Entered as second class matter September 14, 1945, at the post office at Paterson, N. J., under Act of August 24, 1912.

Is there a way to get 4 times the service from things made of steel?

The answer to this question may soon affect your life...*and* your pocketbook. Because there is a remarkable discovery that will enable you to get up to *4 times the service* from items made of steel! From washing machines, automobiles, hardware, wire fencing, screens—dozens of products whose life was formerly cut short by rust.

The remarkable discovery is CORRONIZING, a new process that *far outlasts other rust-protection coatings.*

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So, for utmost dependability, lasting beauty and safety in things made of steel, wisely inquire whether they are made of "Corronized" steel. If they are, you'll be the winner in years of service . . . *by as much as 4 to 1!*

Standard Steel Spring Co.

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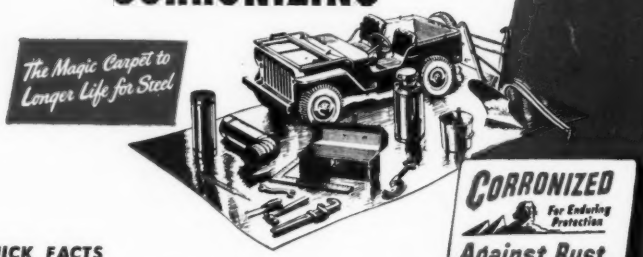
CORRONIZING



QUICK FACTS

CORRONIZING provides a permanent alloy "armor" with 5 layers of defense against corrosion! It becomes part of the steel base . . . can be worked in any manner. Permits using lighter materials by prolonging steel's period of greatest strength. Write for samples and complete information.

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Enjoy all these advantages with *Anaconda Copper Anodes*

Anaconda Copper Anodes—whether Sheet, Oval, or Electro-deposited —contain less than 0.01 percent of total metallic impurities. This unexcelled high degree of purity pays you with the following advantages:

1 Copper goes into solution faster and more uniformly.
2 The highest quality deposit is produced in the shortest possible time.
3 Slime is reduced to an absolute minimum.
4 Spotting and discoloration of the deposit are eliminated.
5 Scrap losses are exceptionally low.

American Brass produces a complete line of Copper, Brass, and Bronze Anodes . . . rolled Sheet or Oval . . . cut to your own specifications or standard sizes . . . drilled or undrilled . . . with or without hooks—also Electro-deposited Anodes. For present or future reference, write for Publication C-5.

ANACONDA

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General Offices: Waterbury 88, Conn. • *Subsidiary of Anaconda Copper Mining Company.* In Canada: ANACONDA AMERICAN BRASS LTD., New Toronto, Ont.

ALSOP

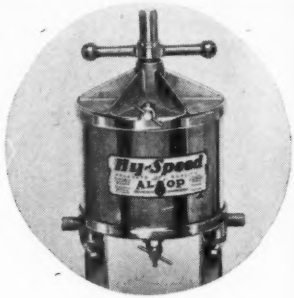
"Sealed-Disc"

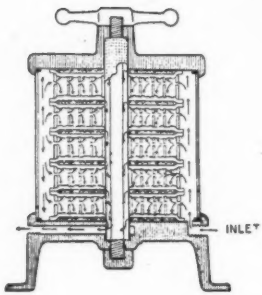
FILTER

•

CLEANS

SURE and FAST



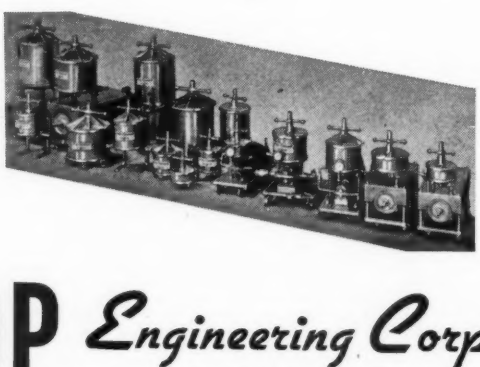


Dirt in the bath is the nemesis of the plater. And the ALSOP Sealed-Disc FILTER is the nemesis of dirt, any kind of dirt or oil impurities that can get into or develop in a plating bath.

The principle of ALSOP Sealed-Disc FILTRATION involves a series of fiber discs, each graded from loose-packed to close packed. The loose-packed side faces outward to catch the coarsest particles. Each cell presents two large surfaces of filter area, thus providing exceptionally high capacity for a given volume. Changing of discs is simple and involves no loss of solution.

So many of the ALSOP Sealed-Disc FILTERS are now in service in plating shops that the type can be considered as standard practice. It has earned the reputation for sure, fast, clean filtration of plating baths.

ALSOP for "Hy-Speed" FILTRATION and MIXING



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Assures Proper Cleaning and Conditioning

NECESSARY FOR PAINT PERMANENCE

War Materiel—cleaned and conditioned with products and processes developed by the ACP Laboratories and Technicians—was successfully preserved from rust and corrosion when shipped to war zones in every clime, from Arctic cold to the humid Tropics.

These new or improved ACP products and methods are available to peacetime metal fabricators to speed production, lower costs and assure better and more durable paint finishes.

210-A DEOXIDINE has a double action. It removes mill oil, drawing compounds and shop soil from the metal and at the same time prepares the surface properly for finishing.

No unusual equipment is required in this simple process. A three or four stage power washer constructed of mild steel (such as is used with alkalies) may be used.

210-A DEOXIDINE process is simple, economical, effective, and requires a minimum of labor and floor space. Our Technical Department will gladly assist you in making the most effective application of our products to your requirements. Write to Dept. N-11

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Take your pencil and check YOUR operation

☐ **Matte etching of aluminum before finishing**
OPTIMUS Cleaner No. 210 cleans and etches aluminum surface in one operation, saving pre-cleaning. Results in a high-grade matte finish. By varying degree of temperature and time, character of etching can be governed.

☐ **Cleaning magnesium prior to anodizing**
Electro-cleaning with OPTIMUS Cleaner No. 221 completely removes all chrome pickle, identification paint and grease, prior to chromic acid dip and anodizing. Complete cleaning insures proper action of anodizing solution and longer salt spray test life.

☐ **Soak and electro-clean prior to plating**
OPTIMUS Cleaner No. 1A10 handles a wide variety of metals. Cleans steel and non-ferrous metals by either soak or electro-clean, or combination of both. Ideal all-around material for job shop or plating department having a wide variety of metals to clean before plating.

☐ **Cleaning die-castings prior to plating**
OPTIMUS Cleaner No. 101A is ideal as a soak cleaner to treat polished die castings before plating. It cleans completely and leaves a bright surface. Can also be used as an electro-cleaner on the same application.

☐ **Surface preparation of aluminum prior to welding, anodizing, painting**
OPTIMUS Aluminum Pre-Cleaner easily and completely removes shop dirt, cutting oil, grease and identification paint. OPTIMUS Aluminum Deoxidizers remove oxide in a cold solution leaving surface smut-free. The weight loss is negligible and the surface resistance low. It completely conditions for Alrok, anodizing, painting and spot welding.

☐ **Cleaning die castings prior to protective coating**
A dip in a solution of OPTIMUS Cleaner No. 221 thoroughly cleans and imparts a slight etch to surface so that protective finishes can be better bonded to surface. Cleans and etches in one operation.

☐ **Welding flux and welding or brazing scale removal**
OPTIMUS Deoxidant No. 3 removes most flux, welding and brazing scales in from 5 to 15 minutes leaving little or no smut. No annoying or corroding fumes. Simply deoxidize and follow with quick hot water rinse.

Write today for full details as to how similar results and savings can be made in your plant.

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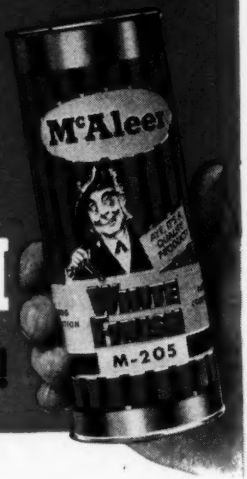

PRODUCING a brilliant, undistorted finish on nickel, brass, copper and softer metal surfaces demands that extreme care be used in selecting the "right" composition to do the work. Ease of cleaning, a most desirable and vital factor, must also be kept in mind if production costs are to be held to a minimum.

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ZINC PLATING PROCESSES!

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- the only process yielding brilliant zinc deposits direct from the bath *without bright dipping!*
- baths are easily made up from prepared salts.
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- satisfactory for use with almost all types of ferrous metals.

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- bright, lustrous deposits of pure zinc, readily obtained on almost all types of steel.
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- easy to operate and control—gives good results over a wide range of operating conditions.
- rapid rate of deposition over wide operating range.

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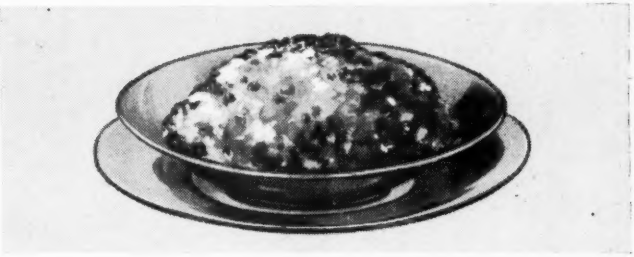
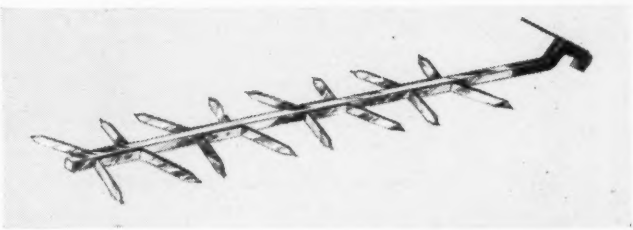
The proof of the pudding . . .

is the eating!



The proof of rack insulation . . .

is the using!



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. . . do the Whole Job and do it Right

Your electroplating bath must be clean to begin with. But, equally important, it must continue to *keep* clean. Otherwise, impurities will collect, and production troubles will be sure to follow.

DARCO S-51 enables you to produce high quality plating *continuously*. Its high adsorptive quality removes, and *keeps removing* grease, oil, soap, colloids and other decomposition products that cause pitting, spotting, poor adhesion.

DARCO S-51 is an activated carbon that is used in cleaning many kinds of plating solution—bright nickel, cyanide zinc, cadmium, copper, iron, gold, silver. It does a top-notch job at a cost of only a few cents a week.

Darco activated carbon is a fine black powder. It is used in conjunction with a filter. For detailed directions send for copy of an article, "Physical Removal of Impurities from Plating Solutions."

It keeps your plating bath as clean as the water used in your final rinse—and no purifying agent can do more than that. Banish halfway cleaning jobs that cause "ghosts" and rejects! Order DARCO S-51 from your dealer, or write direct for a sample. If you have a troublesome purification problem, we'll be glad to give you special assistance.

(This trademark identifies the genuine. Accept no packages without it.)

DARCO

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We invite inquiries regarding your finish needs, present and future.

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Now as American industry swings back to production for peace, "quality" and "Egyptian" continue to be synonyms.

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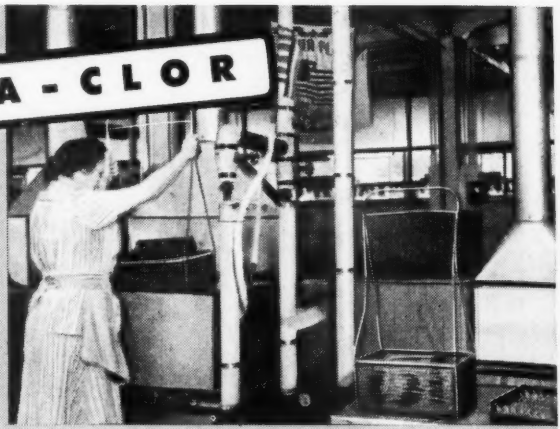

Cleaning precision lenses at Ilex Optical Company, Rochester, N. Y.

THE removal of blocking pitch from precision lenses is one of the toughest applications for solvent vapor degreasing. Practically every known hazard that would contribute toward solvent breakdown is present.

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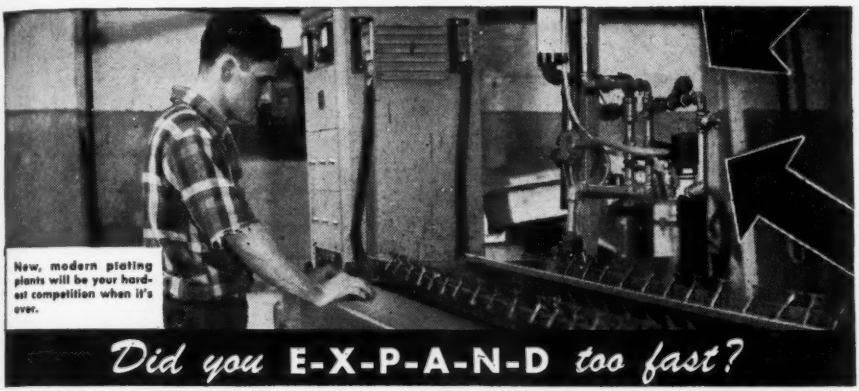

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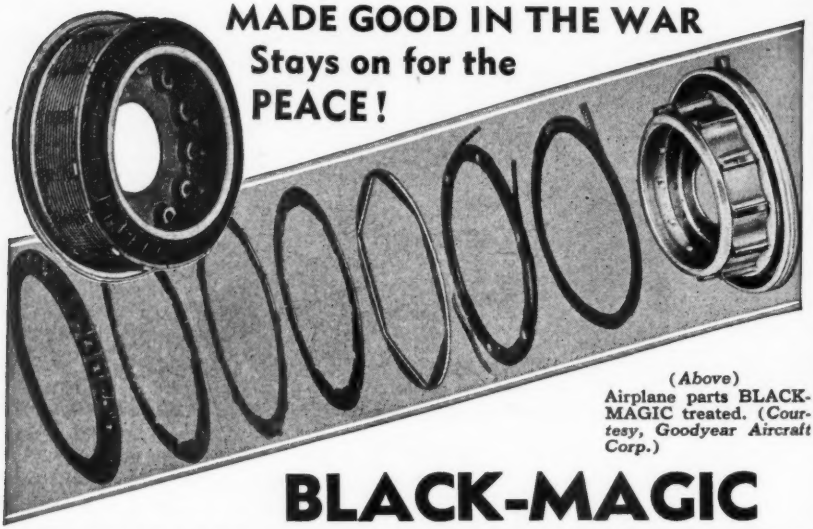

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THE FUNDAMENTALS OF CHEMISTRY FOR ELECTROPLATERS

PART XXII

ELECTRONS AND VALENCE

Samuel Glasstone, D. Sc. Ph. D.

The Arrangement of Electrons

THE next matter to consider in connection with the problems of atomic structure is the arrangement of the negatively charged electrons which surround the nucleus. As seen in the preceding article (Part XXI, MONTHLY REVIEW, Oct., 1945), the number of electrons is equal to the atomic number of the element, and consequently it increases steadily from one, in the hydrogen atom, to ninety-two, in the uranium atom. It is reasonable to expect that these electrons will be arranged in definite layers or groups, and this expectation has been borne out by the results of many observations on the chemical and physical properties of the elements. It is unnecessary to enter into the details of the arguments here; it is sufficient to state that much information has been obtained concerning the configurations or arrangements of electrons in atoms by studies of the spectra, that is, of the characteristic rays of light, produced by the elements under a variety of conditions. In addition, useful data have been derived from the X-rays that result when a given element is bombarded by the stream of electrons which constitute the cathode rays in a discharge tube (see Part XX, June, 1945).

Electron Groups

At the present time the electronic structures of all the known elements have been worked out in great detail, the electrons being divided into six main groups, each of which may have one, two, three or four subgroups. Although the details are of great importance in some aspects of chemistry, only a few of them are of sufficient interest to merit consideration in these articles, and they will now be described. It appears, in the first place, that the electrons tend to arrange themselves in groups or shells, each group or shell being capable of accommodating a definite, but limited, number of electrons. The first, and smallest, shell can hold only two electrons. The next group is able to contain a maximum of eight electrons, the third group eighteen electrons, and the fourth group thirty-two electrons. These numbers have a simple relationship, as may be seen in the following manner: $2 \times 1 \times 1 = 2$; $2 \times 2 \times 2 = 8$; $2 \times 3 \times 3 = 18$; $2 \times 4 \times 4 = 32$. Although the third and fourth shells can accommodate eighteen and thirty-two electrons, respectively, it is found that a very stable arrangement results from a group of eight electrons. The group of eight, frequently referred to as an "electron octet," plays an important role in atomic structure, for it is associated with exceptional chemical stability.

Filling up of Electron Shells

With increasing atomic number, that is to say, as the number of electrons increases, the electrons enter and gradually fill up the successive shells. When the first is complete, with two electrons, the third electron enters the second shell, and so on; when the second shell is complete, with

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eight electrons, the eleventh electron goes into the third shell, and so on. This leads to the following arrangement of the electrons in the first eighteen elements:

Element	*Shell 1*	*Shell 2*	*Shell 3*
Hydrogen	1	—	—
Helium	2	—	—
Lithium	2	1	—
Beryllium	2	2	—
Boron	2	3	—
Carbon	2	4	—
Nitrogen	2	5	—
Oxygen	2	6	—
Fluorine	2	7	—
Neon	2	8	—
Sodium	2	8	1
Magnesium	2	8	2
Aluminum	2	8	3
Silicon	2	8	4
Phosphorus	2	8	5
Sulfur	2	8	6
Chlorine	2	8	7
Argon	2	8	8

Since the third shell can hold up to eighteen electrons, it might be imagined that in the element following argon, that is, potassium, the additional electron would also enter the third shell. Actually this is not the case. It appears that at this point it is easier for the electron to enter a new shell — the fourth — rather than to continue the existing (third) shell. The same is true for the succeeding element, calcium, but with the next element, scandium, the extra electron does, in fact, continue to fill up the already partly completed third shell. From here on the situation becomes somewhat complicated and need not concern us further. It should be mentioned. however, that whenever the outermost shell contains eight electrons the resulting atoms are highly inactive. The corresponding elements, namely, neon, argon, krypton and xenon, in addition to helium which has only two electrons, form no stable compounds. They are all gases which are found to a small extent in the air, and are consequently called the "inert gases of the atmosphere."

Formation of Ions

It is evident that, apart from the group of two electrons in helium, a group of eight electrons, i.e., an electron octet, tends to confer great stability. As a consequence, when atoms of different elements combine with one another, they frequently do so in such a manner as to acquire an electron octet in their outermost shell. It will be seen from the table given above, for example, that the element sodium, with the electronic arrangement 2-8-1, has one electron in excess of the group of eight in the second shell. When it enters into chemical reaction, therefore, the sodium atom tends to lose an electron, leaving 2-8, with a complete octet. Since an electron carries a single negative charge, the loss of the electron will leave the sodium with a single positive charge; the resulting particle is known as a sodium ion, and is represented by the symbol Na^+. Other univalent ions (see Part VIII, June, 1944), carrying a single positive charge, e.g., potassium ion (K^+), are formed in a similar manner. If the atom has two electrons in excess of the octet, as is the case with magnesium (2-8-2) or calcium (2-8-8-2), the atom tends to lose two electrons, forming a bivalent positive ion, i.e., Ca^{++} and Mg^{++}, carrying two positive charges. A few positive ions can be formed by the loss of three electrons from an atom, and still less by the removal of four electrons. Such ions are not common because as the residual positive charge increases, the removal of a negative electron, against the increasing electrical attraction, becomes more and more difficult.

So far there has been considered the acquisition of a complete external octet by the loss of electrons; it is also possible for this condition to be realized by the gain of one or two electrons by an atom. For example, the chlorine atom (2-8-7) has a deficit of one electron; if it could gain this from another atom, e.g., a sodium or potassium atom, which has a tendency to part with one electron, the result will be a negatively charged, univalent chloride ion (Cl^-), with the electronic structure 2-8-8. In a similar manner the sulfur atom (2-8-6) can form the bivalent, negatively charged ion S^{--} (2-8-8) by the gain of two electrons. It is seen, therefore, that simple negative ions can be formed by the addition of electrons to the corresponding atoms. More complex ions, such as sulfate

(*Continued on page* 1103)

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(SO_4^{--}), nitrate (NO_3^-) and carbonate (CO_3^{--}), are formed in an analogous manner by the addition of electrons to a group of atoms instead of to a single atom.

Electrovalence and Covalence

The formation of positive and negative ions, as described above, can be used to explain the structure of salts (Part XV, January, 1945). Every salt consists of a metallic (basic) part and a nonmetallic (acidic) part; in general, the former is a positive ion and the latter is a negative ion, the two parts being held together by forces of electrical attraction. These two (or more) oppositely charged, stable units, i.e., the ions, can combine to form a stable compound, i.e., the salt. This type of combination, which constitutes the structural basis of nearly all salts, is known as "electrovalence," since it depends essentially on electrical attraction.

It should be emphasized at this point that not all elements are able to lose or gain electrons and thus form ions. For instance, the carbon atom would have to gain or lose four electrons, while the nitrogen atom would have to gain three electrons or lose five, in order to secure a structure with a stable octet. As already indicated, the loss of three or four electrons is uncommon, and the same is true for the gain of three or four electrons by an atom. In cases of this kind there is an alternative method available for the completion of the electron octets; this is by two atoms sharing electrons with one another. For example, the carbon atom can acquire the four additional electrons it requires to complete its octet by sharing two electrons with each of two oxygen atoms, since these atoms each require two electrons to fill their respective octets. In this way is formed the familiar gas carbon dioxide, CO_2. The type of combination based on the sharing of electrons is referred to as "covalence." It occurs in such familiar substances as water and ammonia, and in many other compounds that are not salts or salt-like in nature. The tendency for an atom to complete its octet, in one way or another, accounts for the great majority of compounds formed by the elements of low atomic weight. With the heavier elements certain complications arise which make other groups of electrons possible as stable configurations, but the essential distinction between electrovalence and covalence, as being due to electrical attraction and to the sharing of electrons, respectively, is retained.

As a result of the different ways in which the units can be held together, there is an important difference between electrovalent and covalent compounds which is of interest to the electroplater. Because the former consist of electrically charged ions, they are able to conduct the electric current when dissolved in water, whereas covalent compounds cannot do so. It is for this reason that salts, the formation of which almost invariably involves electrovalence, are the basis of electroplating solutions.

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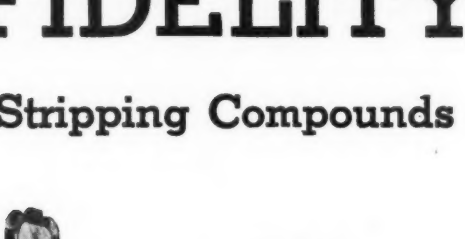

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A Modified Salt Spray Test For Chromium Plated Zinc Base Die Castings

By C. F. NIXON*

ZINC base die castings, plated with copper, nickel, and chromium, which are subjected to outdoor exposure, sometimes develop blister-like eruptions on the surface after a period in use. It is generally accepted, and it seems evident, that this type of disfiguration is a form of corrosion. Plated die castings do not often fail when used, for example, inside an automobile body, although more heavily plated castings used on the exterior of the same car may fail. Further, it has been observed that similarly plated castings on outdoor exposure fail at a different rate, depending upon the exposure locality.

However, the standard 20% salt spray accelerated corrosion test produces a plate failure which is quite different in appearance. The appearance of white zinc salts ordinarily considered to be evidence of failure are usually not accompanied by the formation of blisters, even though the test be continued for many hours after white products of corrosion have been observed. Further, it has not been possible to secure correlation between service life and salt spray life. The usefulness of the standard salt spray test in this connection seems limited, therefore; it does not serve to probe the outstanding weakness exhibited by the type of plated part under consideration.

An effort was made, before the war, to find an accelerated corrosion test which would more closely simulate actual exposure conditions. This sought-for test should, it was thought, porduce the type of failure found in the field and, as a corollary, afford a means for predicting service life.

Because of its present universal application, the 20% salt spray test was used as a starting point. It was thought that the desired results could perhaps be obtained by modifying the formulation of the spray solution only. Of the many things tried, it was found that a spray solution containing 1% of glacial acetic acid in addition to 20% of common salt (pH 3.2) was most satisfactory. Electrodeposits tested in this fog failed because of blister-like eruptions very similar in appearance to those which occur in service. In addition, the time required to produce failure bore a reasonably consistent relationship to field performance. It was found that copper, nickel, and chromium plated zinc base die castings that withstand a 24-hour exposure in the acetic acid salt spray at $120 \pm 5°F.$ may be exepected with some assurance to be in good condition after a year of exposure in Detroit or in Florida. Conversely, plated castings which blister in less than 24 hours of exopsure in this accelerated test may be expected to fail due to blistering after less than a year's exposure in Detroit or in Florida. It was found, with reasonably good uniformity, that deposits of a total thickness of .0008" minimum and a copper plate thickness of .0002" minimum will pass a 24-hour test. Deposits substantially exceeding .001" in total thickness may be expected to withstand 48-hour exposure in the acid salt spray and may be expected to do correspondingly better in service.

If this much be true, then the acid salt spray is a new tool which should prove useful. Factors other than plate thickness, such as alloy composition, casting procedure, polishing procedure, cleaning procedure, and plating procedure, may be studied more readily. It is to be understood that insufficient work has been done to date to warrant full acceptance of this modified salt spray either as a development or an inspection tool. Indeed, it is with this thought in mind that it is offered here for consideration. It is hoped that others will test the test; the work of no one laboratory is sufficient to bring about general acceptance of a testing method.

Following is a discussion of the consider-

*Process Engineer, Fisher Body — Ternstadt Div., G. M. C., Detroit.

ations which lead to the formulation of the acetic acid salt spray: Through metallographic examination of cross-sections taken through blistered spots and macroscopic study of the surface appearance of plated castings which have been exposed out of doors, it is possible to form an opinion as to the mechanism by means of which blister-like eruptions form. First a small hole appears on the surface. It may penetrate to the base metal or it may be stopped off when it reaches the upper most surface of the copper plating. If the hole reaches the base metal then corrosion of the zinc base alloy starts, pitting the base metal and spreading out under the adjacent sound plating. As corrosion products form, the deposit is pushed up producing a blister. Fine cracks in the plate may radiate from the hole in the center of the blister. Depending upon the thickness of the plate, that portion of the deposit which forms the blister may fall away, leaving a comparatively large black spot on the surface of the casting. Castings having but .0002" of nickel plus chromium, with or without a flash of copper underlying the nickel, blister rapidly; but because of the brittleness of the thin metal forming the blister it falls away in a short time. Such plated

TABLE I

EXPERIMENTAL SALT SPRAYS

Spray Solution	*Temperature*	*Time (Hr.)*	*Observations*
1. 20% Salt plus SO_2 to saturation	Room	48	Discoloration and blistering, odor unpleasant.
2. 20% Salt plus H_2SO_4, pH 6.0	Room	48	Discoloration, no blisters
3. 20% Salt plus H_2SO_4, pH 6.0	120°-140°F.	48	Discoloration, no blisters, some pitting.
4. 20% Salt plus 1% conc. H_2SO_4	Room	48	Discoloration, no blistering, chro- and nickel salts formed.
5. .75% Sodium bisulfite, no salt	Room	48	Blisters similar to those found in field, odor unpleasant.
6. .75% Sodium bisulfite, no salt	120°-140°F.	48	Blisters similar to those found in field, odor unpleasant.
7. 10% Sodium acetate, no salt	140°F.	96	Occasional fine blisters.
8. 20% Salt plus 1% acetic acid, pH 3.2	Room	72	Blisters similar to those found in field, no staining.
9. 20% Salt plus 1% acetic acid, pH 3.2	120°-140°F.	24 48	Blisters similar to those found in field, no staining.
10. ½% Acetic acid pH 3.2 no salt	Room	48	Blistering, but appearance not typical.
11. ½% Acetic acid pH 3.2, no salt	120°-140°F.	24 48	Blistering, but not typical, action too violent.
12. 20% Salt plus ½% acetic acid	120°-140°F.	24 48	Blisters similar to those found in field, no staining. Very similar to results obtained with 1% acetic acid.

castings soon appear speckled with blackened areas of exposed casting. Blisters which form in deposits approaching .001" in thickness stay in place for a considerable time. Surfaces not frequently handled or cleaned may also be discolored, presumably due to seepage of copper salts. The base metal under a blister (a film of base metal always adheres to the copper plate), as may be observed when the loosened plating is carefully removed, is usually dark in color but may exhibit light-colored rings concentric about the central pit.

Investigation indicates that failures most readily occur in industrial regions and there, more particularly, in the winter.

Test pieces examined in February appear about the same whether the period of exposure has been three months' or ten months' time. Florida test field failures are less severe for a given period of time than those which develop during the same time in Detroit.

Pieces exposed in rural localities do still better. Deposits as thin as .0002" total have been observed to be in good condition after 15 months of rural exposure. One of the principle differences between an industrial atmosphere and other atmospheres lies in its acid content. This is due, among other things, to the fact that a great deal of coal is burned every day in such an area. Even snow gathered from roof tops may, when melted, have a pH of less than 7.0. Therefore, it was thought that service conditions might be duplicated by acidulating the salt spray. Some of the variants tried are listed in Table I. In no case was the sprayed solution used more than once, nor did the spray impinge directly on the test specimens. The total plate thickness varied from .0002" to .001". in.

On the basis of these and other experiments, it was decided that it would be worthwhile to attempt correlation between test results and exposure results using 1%

TABLE II

RELATION BETWEEN PLATE THICKNESS AND ACID SALT SPRAY RESISTANCE. ALL SPECIMENS CHROMIUM PLATED, TO APPROXIMATELY .00001 INCH. SALT SPRAY: 20% COMMON SALT, 1% ACETIC ACID, TEMPERATURE 120° F. ± 5°

Group No.	*Plate Thickness, in.*			*Appearance after 24 Hours*
	Copper	*Nickel*	*Total*	
1	Flash	.0003	.0003	Blistered
2	.00005	.0006	.00065	Blistered
3	.0001	.0002	.0003	Blistered
4	.0001	.0004	.0005	Blistered
5	.0001	.0005	.0006	Blistered
6	.0001	.0006	.0007	Blistered
7	.0001	.0008	.0009	Few fine blisters
8	.0002	.0002	.0004	Blistered
9	.0002	.0004	.0006	Blistered
10	.0002	.0005	.0007	Few fine blisters
11	.0002	.0006	.0008	Few fine blisters
12	.0002	.0007	.0009	OK
13	.0002	.0008	.0010	OK
14	.0003	.0002	.0005	Blistered
15	.0003	.0003	.0006	Blistered
16	.0003	.0004	.0007	Blistered
17	.0003	.0006	.0009	OK
18	.0003	.0008	.0011	OK
19	.0003	.0010	.0013	OK (after 48 hrs.)
20	.0004	.0002	.0006	Blistered
21	.0004	.0004	.0008	Few fine blisters
22	.0004	.0006	.0010	OK
23	.0004	.0008	.0012	OK (after 48 hrs.)

of acetic acid added to the regular 20% common salt solution. 120°F. was selected as the standard temperature because it is easier to maintain than is 140°F. Room temperature operation, of course, is still easier, but action is too slow.

In Table II acid salt spray results are listed for automobile parts (outside door handles) plated to different thicknesses as shown. The alloy used was No. XXI of ASTM Designation B86-43 containing approximately 4% aluminum and 3% copper. The plating procedure was conventional and in commercial use at the time. Having been degreased in organic solvent the parts were given a cathodic electrocleaning. Following this, the parts were rinsed, acid dipped, rinsed, cyanide copper plated, rinsed, semi-bright nickel plated, rinsed, dried and buffed and then chromium plated. For each item in the table at least three samples were tested.

Many specimen parts have been examined after plating failure has occurred, either as a result of a year's exposure in Detroit or in Florida or as a result of an indefinite period of exposure on an automobile. Very often is was observed that while a portion of the surface of a given piece had failed, other surface areas were still in good condition. In nearly every case the total thickness of the deposit in the failed areas was under .0007" — and in nearly every case the total plate thickness in good areas was over .0007". For example, results obtained when a group of 50 parts returned from service were examined are given in Tables III and IV. At least a portion of each part was blistered.

TABLE III

RESULTS OF EXAMINATION OF FAILED AREAS ON 50 PARTS RETURNED FROM SERVICE AFTER ONE YEAR.

	Plate Thickness, in.		
Coating	*High*	*Low*	*Average*
Copper	0.00023	0.00004	0.00011
Nickel	0.00076	0.00027	0.00035
Total	0.00081	0.00034	0.00046

The results cited tend to emphasize the importance of plate thickness and also to confirm the hope that a correlation would be found between the acid salt spray data and field performance.

TABLE IV

RESULTS OF EXAMINATION OF SOUND AREAS ON 50 PARTS RETURNED FROM SERVICE AFTER ONE YEAR

	Plate Thickness, in.		
Coating	*High*	*Low*	*Average*
Copper	0.0024	0.00011	0.00018
Nickel	0.00109	0.00054	0.00072
Total	0.00129	0.00070	0.0009

Acknowledgment is due Mr. Alexander C. Nixon, now with Fisher Body in Detroit, for the dominant part he played in planning and carrying out this work.

Correction For Speakers List Branch Educational Activities

After the speakers' list published in the September REVIEW went to press, Mr. W. L. Cassell changed his connections. For speaking engagements on Plating Equipment he should be addressed at Lea Manufacturing Company, 16 Cherry Avenue, Waterbury 86, Connecticut.

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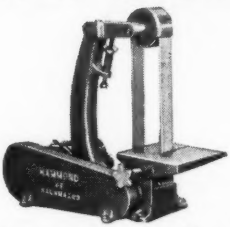

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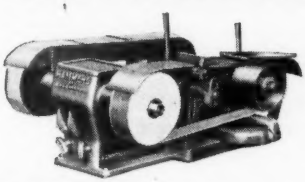

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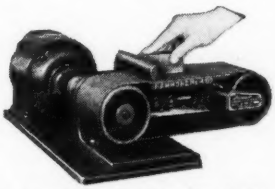

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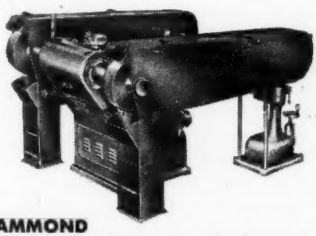

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MANUAL OF OPERATION FOR SALT SPRAY TESTING EQUIPMENT

By H. P. TROENDLY*

Introduction

A S.T.M. Specification B117-44T (revised June, 1944)[1] is an excellent and complete specification for salt spray testing. Unfortunately, the function of this specification required it to be expressed in general terms.

We of the Spring Division, Borg-Warner Corporation, using this specification as a yardstick, undertook about eight months ago to re-build our salt spray cabinet to secure the intended results. We also undertook to coordinate our results with those obtained in the salt spray room at Rock Island Arsenal and in the large, elaborate cabinet at Parker Rust Proof Company in Detroit.

After about seven months of work interpreting the subject matter of the bulletin into actual construction and operation of a salt spray box, we finally arrived at a point where fairly comparable results could be consistently obtained in all three of the boxes referred to above.

During the course of this work, it became increasingly apparent that someone would have to specifically list and evaluate certain factors vital to the operation of a salt spray cabinet. It was obvious that unless these operational details were explained and standardized in a manual, every facility would be exposed to the same headaches of trial and error that we encountered. With this in mind, the .50 Cal. Metallic Belt Link Committee asked its Engineering Sub-Committee to investigate and make the necessary recommendations. The resulting recommendations are listed in the Appendix to this Manual.

The instructions for operating a salt spray cabinet were prepared jointly by Mr. W. R. Cavanagh of the Parker Rust Proof Company and Mr. W. A. Schumacher, Metallurgist of the Spring Division, Borg-Warner Corporation. These instructions were carefully reviewed and edited by Mr. Harry Faigen of the Rock Island Arsenal and Mr. J. W. MacAllister, Jr. of the Industrial Filter and Pump Manufacturing Company. These instructions represent the combined experience of the above parties.

In order to make this Manual complete in all respects, we have drawn heavily on the A.S.T.M. Designation B117-44T for many portions.

Instructions For Operating A Salt Spray Cabinet

General Description and Installation of Cabinet

The salt spray cabinet should meet the American Society for Testing Materials specifications as outlined in A.S.T.M. Designation B117-44T.

The Appendix contains an outline of seven important factors which must be controlled in a salt spray box in order to develop satisfactory salt spray testing information, and also nine recommendations to be followed in the building of a salt spray unit.

It is advisable to install the box in an evenly heated area. The cabinet should be vented to the outside air.

The air line connections beginning with the scrubber outlet and extending through the air pressure regulator, the saturator tower and into the box, including all connections within the box proper, must be of non-corrodible material such as Monel. Air lines outside the box may be copper or brass.

It is advisable that the air line connecting the saturator and the cabinet be as short as possible and insulated to prevent heat loss. Heat loss along with resultant possible excessive condensation may tend to defeat the purpose for which the saturator tower was intended.[2]

Provision should also be made for a

*Vice President and General Manager, Spring Division, Borg-Warner Corporation, Bellwood, Ill., and Chairman, Production Engineering Sub-Committee, .50 Cal. Metallic Belt Link Committee of U. S. A. Ordnance Department.

thermometer well installation at the point where the air line enters the salt spray cabinet in order that the air temperature at that point may be measured and controlled.

The salt spray cabinet should be installed in such a location that escaping salt fog cannot damage valuable adjacent equipment or supplies.

Starting the Cabinet

Prepare a salt solution by dissolving 20 ± 2 parts by weight of salt in 80 parts by weight of distilled water or city water containing not more than 200 p.p.m. of total solids. Your local water department can furnish information as to total solids content. Approximately two pounds and one ounce of salt per gallon of water will produce the 20% solution required. The salt used shall be sodium chloride containing on the dry basis not more than 0.1% sodium iodide and not more than 0.2% of total impurities. Morton Salt Company Butterflake Grade Salt should meet the above requirements.

(Ed. Note: Undoubtedly other large salt refiners offer equivalent grades.)

It is felt that most facilities should use distilled water both in the saturator tower and in making up salt solution. This is believed necessary because of variations in city waters. City water which meets the purity requirements specified in A.S.T.M. Designation B117-44T may be used.

The salt solution must be filtered before being placed in the cabinet reservoir. Silk or similar cloth makes an excellent filter.

The saturator tower should now be filled to about 2/3 capacity with water, and heated to a temperature of 100°F. The thermostat or heat control should be set to maintain that temperature temporarily.

Inspect and install the spray nozzle, making sure that it is clean. It is advisable to affix a silk or similar filter covering over the open end of the supply pipe to the spray nozzle to prevent pick-up of solids which may stop the spraying. Tentatively adjust the nozzle so that when spraying commences the spray will be directed against either a suitably provided baffle plate or a side of the cabinet. The nozzle should be directed either horizontally or slightly upward.

The compressed air supply provided to operate the cabinet must be free from oil, dirt, or compressor condensate. This can be accomplished by passing it through a water scrubber or a tower containing at least two feet length of a suitable cleaning material such as asbestos, sheep wool, excelsior, or slag wool. A compressed air filter manufactured by any reputable concern, if properly installed and maintained, should perform this function in a satisfactory manner.

Turn on the air and adjust the pressure to between 14 and 15 p.s.i. The nozzle should now be spraying cold salt solution.

Shut off the air and stop spraying.

The salt spray cabinet should then be heated to a temperature of 92°-97°F. as measured by a thermometer placed in the area where the test specimen will be exposed.

The solution in the reservoir should now be checked for salt concentration and pH value. The salt concentration is most conveniently determined with a hydrometer including the specific gravity range 1.126 to 1.157. The solution when heated within the temperature range 92°-97°F. should test within the specific gravity range 1.126-1.157. If it is less, add concentrated salt solution; if it is more, add water. Should it prove convenient to do the testing at a lower temperature, the proper value for any temperature in the range 65° to 110°F. may be obtained by referring to Fig. 1. It is also permissible, if desired, to check salt concentration by titration. Detailed procedure will be given later.

The pH value of the reservoir solution must be maintained between 6.5 and 7.2. The pH measurements should be made colorimetrically using bromthymol blue as the indicator. The La Motte or the Hellige comparators are satisfactory for this purpose. The pH measurements may be made electrometrically provided proper precautions for checking unbuffered solutions are taken.

Should pH adjustments of the reservoir solution be necessary, the following procedure should be followed: To raise pH add 0.05 normal C.P. sodium hydroxide solution. To lower pH add 0.05 normal C.P. hydrochloric acid solution.

Place in the cabinet two fog collecting devices, each consisting of a 10 cm dia. glass funnel inserted into a rubber stopper which in turn is tightly inserted into a

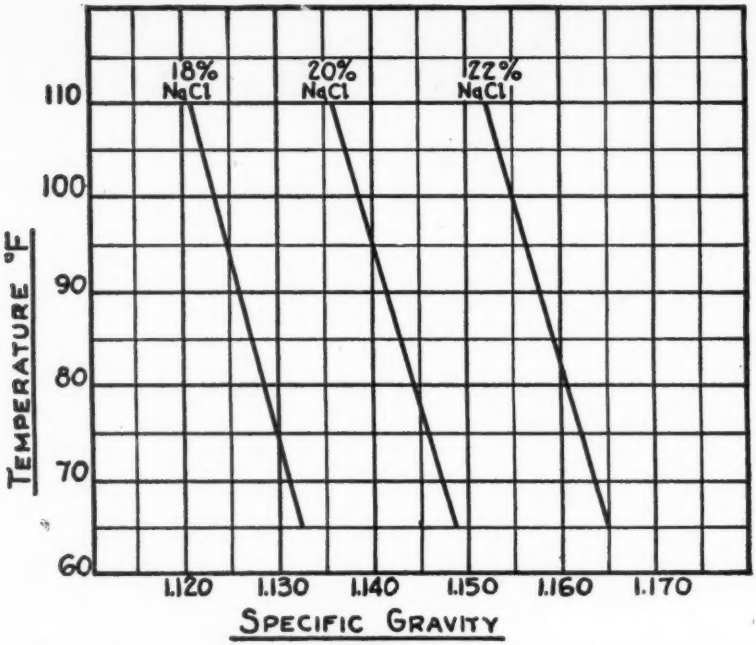


Figure I.
Variation of Specific Gravity of Sodium Chloride Solutions with Temperature. (Prepared from data in International Critical Tables by Rock Island Arsenal)

100 ml graduated cylinder. (Funnels with 10 cm diameter have an area of approximately 80 sq. cm). The funnel top (opening) should be on the same level as the specimens to be tested. Both collectors should be located in the area designed for test specimens, one placed at a point nearest the spray nozzle, and the other at a point most distant from the spray nozzle.

The salt spray cabinet is now ready for a test run. Start the spraying by turning on the compressed air and adjusting the pressure to 14 to 15 p.s.i. The spraying action should be observed and, if necessary, readjusted to prevent direct spray from impinging on the test specimens. It is advisable to operate the cabinet for 24 to 48 hours before placing specimens therein in order that a check be had on the amount and the salt content of the collected fog.

It may be found that the nozzle will not continue to spray satisfactorily. If evidence is found that the nozzle has been plugged with foreign matter, clean the filter on the liquid side of the nozzle. If salt crystals are found on the body of the nozzle, reduce the controlled temperature of the saturator tower by 5°F. If salt crystals are found at the orifice of the nozzle and not on the body of the nozzle, raise the controlled temperature of the saturator by 5°F. Start the box spraying again.

After the cabinet has been in operation for 24 hours, note the amount of collected fog in each of the two collectors. If the amount in either one is out of the specified range (0.5 to 3.0 ml per hour per 80 sq. cm of collecting area), adjustment of the position of the spray nozzle should be made. It is suggested that the included distance between nozzle and baffle plate (or side of tank if baffle plate is not being used) be varied in the following manner: Increase the distance to increase the amount of fog collected; decrease the distance to decrease the amount of fog collected. The collected fog should be checked for salt concentration. This can be accomplished by measuring specific gravity with a hydrometer of proper range, small enough to float in the solution formed by the collected fog. The specific gravity reading must be obtained while the solution temperature is 92°-97°F. Specific gravity should be in the range 1.126-1.157. If the amount collected be insufficient to float a

hydrometer, the salt concentration may be determined by titration as follows:

Pipette 5 ml collected fog solution into a 100 ml graduated cylinder, dilute to 100 ml with distilled water and mix well. Pipette 10 ml of that solution into a 150 ml beaker and add 40 ml distilled water and 1 ml of potassium chromate (containing no chloride), and titrate with N/10 silver nitrate to the appearance of a permanent pink color. Calculate the % salt from the data in Table I.

TABLE I
TITRATION OF SALT SOLUTION

Ml of N/10 silver nitrate added	*% salt in collected fog solution*
15	15.5
16	16.4
17	17.4
18	18.3
19	19.3
20	20.2
21	21.0
22	21.9
23	22.7
24	23.6

Salt concentration in the collected fog should be in the range of 18 to 22 per cent. A salt content in the collected fog solution exceeding that in the reservoir indicates that the system had not been operating at equilibrium and that some loss of moisture from the salt fog particles to the air inside the cabinet had occurred. This condition generally results from the salt solution on the collector evaporating and depositing salt crystals when the box is opened. These crystals will be washed into the fog collector if the box is closed without cleaning and drying the collector. Similarly, a salt content in the collected fog solution less than that in the reservoir indicates that water has been added to the atomized salt particles. This may occur by:

1. Water from the water seal around the cover accidentally being splashed into the fog collector.
2. Malfunctioning of the apparatus intended for the heating of the salt spray box resulting in the following effects:
   a. Over-heating of reservoir salt water causing water vapor to arise and dilute the sprayed salt fog.
   b. Localized over-heating of a box wall area causing fog which contacts that area to evaporate, releasing water vapor to dilute the remaining fog.

Records

It is suggested that the following information be recorded daily:

1. Air pressure.
2. Amount of water used in saturator tower.
3. Temperature of air entering cabinet.
4. Temperature of cabinet — twice daily.
5. Amount of fog collected.
6. Time in which fog was collected (in hours).
7. Fog collected in ml per hour per 80 sq. cm (10 cm funnel).
8. Concentration or specific gravity of fog solution collected.
9. Concentration or specific gravity of salt solution in reservoir.
10. pH of salt solution in reservoir.
11. Amount of 20% salt solution added to reservoir.
12. Other additions to reservoir.

APPENDIX

Salt Spray Equipment Recommendations by Production Engineering Sub-Committee of .50 Cal. Metallic Belt Link Committee

The sub-committee agreed that at least seven important factors *must* be controlled in a salt spray box in order to develop satisfactory salt spray testing information.

1. The compressed air which enters the box must have 84 to 90% relative humidity after its release inside the salt spray chamber.
2. The temperature of the box must be maintained at 95° plus 2° minus 3°F. in such a way that there is no evaporation which will cause a change in the strength of the salt solution due to hot spots in the box.
3. Atomization shall be so arranged and controlled that between ½ and 3 cc per hour of fog is collected in the manner set forth in the latest specifications.
4. The collected fog shall test between 18% and 22% salt.
5. The pH of the salt solution in the cabinet reservoir shall test between 6.5 and 7.2.

6. Specific gravity of the salt solution at 95°F. must be between 1.126 and 1.157.

7. In order to have a box accomplish the above and work without stoppages, the box and humidifier materials must be positively non-corrodible in the salt solution.

The sub-committee, after inspection of the two new boxes at Industrial Filter, one with air strip heaters, and the other with hot water jacket heating arrangement, agreed to several recommendations for new salt spray boxes which an Ordnance facility might contemplate purchasing or rebuilding:

a. The saturator tank must be made of definitely non-corrodible material: Monel, hot tin-dipped copper, or rubber-lined metal. Rubber lining, while it may cost the most, would be by far the surest means of preventing corrosion in the saturator tank.

b. The pipe line from the saturator tank to the nozzle, together with all its fittings, shall be of non-corrodible material. Copper has proved satisfactory so far at Borg-Warner. Industrial Filter's setup made with copper, rubber, and Monel appears satisfactory.

c. The saturated air line from the saturator tank to the nozzle should be insulated and as short as practicable so that the saturated air entering the box can be controlled at temperatures of about 105° to 110°F., which have been found essential for certain nozzle installations. Provision should also be made for a thermometer well at the point where the air line enters the box so that the proper entering temperature can be determined and controlled.

Note that in the final analysis, the temperature and humidity of the ingoing air will have to be adjusted to maintain the proper salt concentration in the collected fog. The temperature of the humidifier water will therefore differ in different boxes and must be adjusted to produce the foregoing conditions.

d. Fixed Monel nozzles are recommended until something better is developed. We also recommend using Spraying Systems nozzles. Referring to Spraying Systems Catalog No. 22, we recommend Syphon External Mixing Nozzle Set-Up No. 2 for Industrial Filter boxes No. 1 and No. 2, and Set-Up No. 3 for Industrial Filter boxes No. 2, No. 4, and No. 6. There are some indications at Parker Rust Proof that a so-called Set-Up No. 3A, which is made up of fluid nozzles No. 2050 and air nozzle 64-5, works equally well. To get a proper fog collection the nozzle should be positioned so that the spray impinges against a baffle. The side of the salt spray box may be used as the baffle if desired.

e. It is recommended that the air pressure be carefully maintained between 14 and 15 p.s.i., as there seems to be critical pressures at 12 p.s.i. and at 16 p.s.i. which produce definitely increased rates of corrosion of materials being tested.

f. All equipment in the box proper, such as nozzles, connections, etc., shall be either Monel or hard rubber.

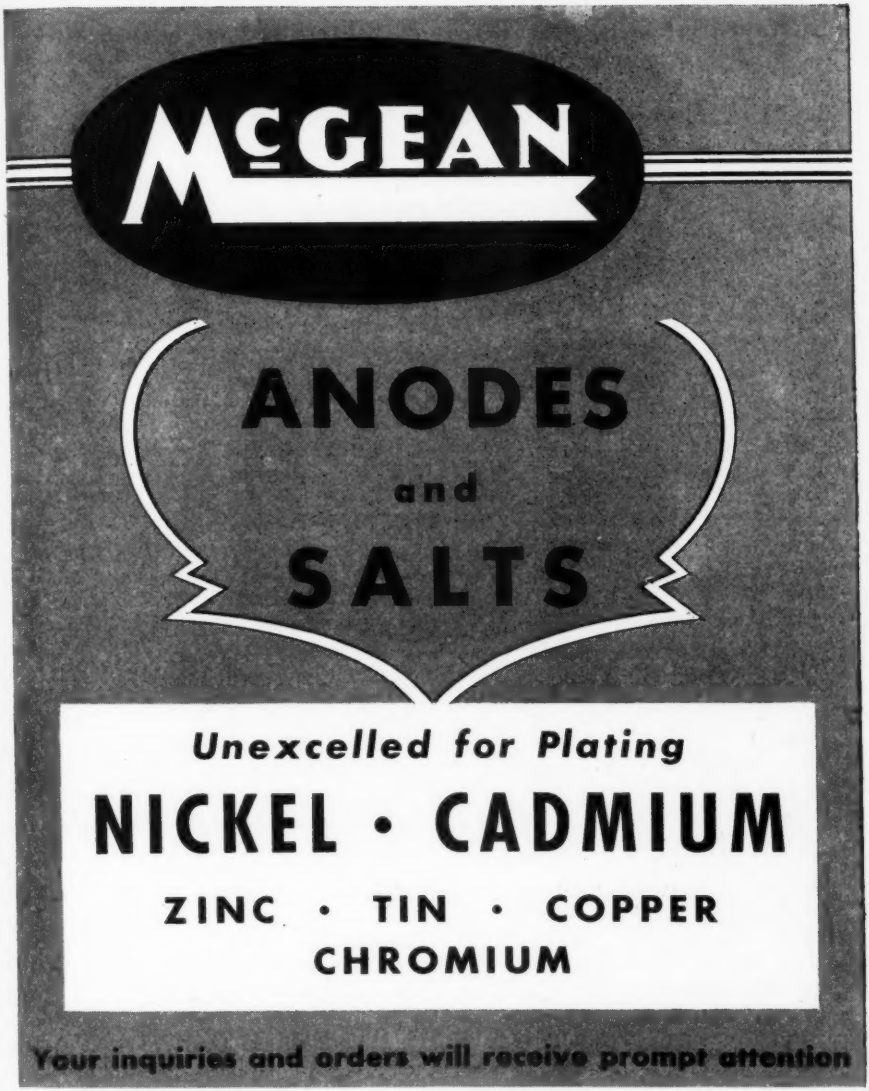
g. For the suction pipe from the salt solution to the nozzle we recommend hard rubber with Industrial Filter's arrangement on the bottom for attaching mercerized cotton or silk cloth over a rubber cap to screen foreign matter out of the system. This cloth screen should be 1½" from the bottom of the solution tank. The solution level should be maintained at between 4" and 12" below the nozzle line.

h. No work should ever be located so that the drippings from it fall into the salt solution reservoir.

i. Heaters or other heating means must be so arranged that there are no hot spots. If there are no hot spots and the saturation point and temperature of the incoming air is controlled as outlined above, a constant salt concentration will be maintained in the reservoir and in the collected salt fog solution. After considerable discussion, we are inclined to strongly recommend the salt spray box heated by a hot water jacket. We also recommend that the control thermostat be located in the water jacket proper rather than inside the salt spray box itself.

References

1. American Society for Testing Materials, 260 S. Broad St., Philadelphia 2, Pa.
2. "Salt Spray Test" by V. M. Darsey, A.S.T.M. Bulletin No. 128, p. 31, May 1944.



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THE ADHESION OF ELECTRODEPOSITS

III. CORRELATED ABSTRACT OF PUBLISHED METHODS FOR MEASURING THE DEGREE OF ADHESION

A. E. S. Research Project No. 3

Project Director: A. L. Ferguson
Associate: Elmer F. Stephan
Chemistry Department, University of Michigan
Ann Arbor, Michigan

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Present status of the problem
Views of Speller
Views of Mesle 1117
Views of Blum
Views of Finkbone 1118
Views of Finkeldey
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GENERAL SURVEY

BEFORE discussing in detail the various methods for measuring adhesion, it is well to survey the situation in a general manner. This can best be done by stating the remarks of a few authorities in their own words.

In his discussion of a paper by A. W. Hothersall,[43*] F. N. Speller (Director of Research, National Tube Co., Pittsburgh, Pa.) summarizes the adhesion situation in the following two sentences:

"It seems to me that two things particularly stand out in this discussion. We need to know more about the fundamental nature of the bond between a surface layer and the metal itself, and, in the second

*Reference numbers refer to "BIBLIOGRAPHY" published in September issue.

place, we need some practical test of adhesion. It is a wonder that we have been able to get along so well without some kind of a standard method of testing adhesion."

F. C. Mesle,[96] of Oneida, Ltd. has the following to say:

"In my judgment, one very essential quality test for electroplating is for the adhesion of the deposit. Stress has been put on thickness specifications and rightly so, but if thickness specifications are to have value, and are intended to protect the base metal from corrosion, it is equally important that specifications for adhesion also be developed.

"In general, if the deposit does not peel or blister in the finishing operations, it is assumed that the adhesion is satisfactory. Factory tests on samples, such as bending, twisting, and burnishing, may, in a general way, indicate a satisfactory adhesion of the deposit, but the fact still remains that much plating is done which lacks the needed adhesion to give satisfactory service or to adequately protect the base metal from corrosion. Look over the automobiles parked in most any lot and you will have proof of this.

"Recently, I inspected 52 automobiles made during the last five years, and found 29 per cent of these cars to have rusty bumpers because the plate had a poor adherence. From eleven of these cars, I could peel the plate with my fingers and get pieces large enough to measure the thickness, which was as follows:

Exhibit No.	*Exhibit No.*
1—.0015″	6—.0005″
2—.001″—.0015″	7—.0008″—.001″
3—.0015″—.002″	8—.001″
4—.001″	9—.002″
5—.0022″	10—.0015″

"All of these meet quality specifications for thickness, yet quality was lacking; the bumpers were rusty, because the deposit was poorly adherent.

"It is assumed that the bumper bars were inspected and showed no indications that the plate would peel or blister and thus allow corrosion to start, under such conditions as corrosion develops, the plate being pushed up by the rust that forms.

"The fact that such a large percentage of non-adherent plating gets out, indicates that there is a need for development of a practical method for testing the adherence of the deposit. Until such a method is developed, it might be wise to develop specifications for processing work through the cleaning and plating to assure a minimum of failures from this cause.

"I do not mean to convey the thought that such failures apply only to the automotive industry. It occurs on other manufactured goods, even at times on silver plated tableware.

"I once wrote an article on 'Plating to Specifications' and in it suggested what I thought was a good test for adherence. I also thought that the idea was original with me; since then, I have learned that I was wrong in both assumptions. The idea was to solder a lug on the surface to be tested for adherence, then pull it off. I even rigged up a gadget so I could measure the pounds' pull required either to fracture the solder or peel the deposit from the base. When I first sought to get advice from authoritative sources, I was told the heat required to solder the lug to the plated surface would affect adversely the adherence of the deposit. Therefore, the test would be without significance. I tried to discover if the heating did affect adversely the adherence of the deposit by heating test pieces to temperatures higher than required to do soft soldering. In some instances, I heated the test pieces to a red heat, and found that after this heating, the adherence was as good as before, so I concluded that the test was satisfactory and proceeded to use it. But, the results were not satisfactory, because some times I was sure the test should show peeling, but it didn't."

William Blum,[31] of the Bureau of Standards, has the following to say:

"No exhaustive or very conclusive measurements have been published upon the adhesion of plated coatings. One reason for this dearth of literature is the difficulty of developing reliable quantitative tests for adhesion of thin layers. The only methods that are even promising are those which depend upon deformation of the base metal and observation of the behavior of the coating. In the absence of quantitative tests of adhesion, most of the published statements on this subject, including those in

this paper, are opinions that are based either on general principles or on qualitative observations and commercial experience."

The galvanizing industry also is confronted with this problem of adhesion and methods for measurement. Methods suitable in this field might be used in electroplating. The zinc people as a group have given more attention to standardizing tests than the electroplaters.

Mr. B. P. Finkbone[65] makes some remarks along this line.

"Differing from other physical properties, the adherence of the coating cannot be determined in absolute units. Efforts to measure progress toward more adherent coatings have, therefore, resulted in many different ways of testing and a variety of methods for describing the results.

"In the past. specifications have been written which have endeavored to cover this question of adherence. In A.S.T.M. Designation A93-27, paragraph 5 (b) covers coating tests as follows."

The specifications are then listed, and the following remarks are made concerning them:

"Although these tests may serve the purpose of detecting obviously inferior coatings, there is no doubt that their severity in no way approaches the severity of commercial forming and drawing operations which are met in present day use of high speed presses and forming machinery. A further consideration of these methods indicates that the personal element enters into the forming and inspection of the bends, since a wide variation is likely to occur in the way in which the bends are made."

In discussing the paper by Finkbone, W. H. Finkeldey makes the following remarks:

"I am very glad to hear Mr. Finkbone bring out the point that some type of standard test procedure to determine the adherence of zinc coatings is necessary. I don't know of any single thing, in my limited experience with zinc coating over a few years, that would more quickly allow both the people using zinc coatings and those who are working with them in research laboratories to try to do something to improve them or what would allow them to more quickly arrive at a good result. I know of nothing better for that than a good standardized test for adherence of zinc coatings.

"I think it is time somebody developed a test that we can all use pretty much as the Erichsen test is used today. The methods used today are not suitable for zinc. When that day comes, we will all be helped a great deal in our study of galvanized coatings."

As an introduction to the detailed discussion of each of the various methods for measuring adhesion it is well to make a list of the methods and some brief remarks concerning them. This is well presented in a communication from F. C. Mesle and follows:

"In most cases if the bond between the base and the electrodeposited metal is not good, the plating job is a failure; hence the importance of adequate test methods.

"The problem is to find a test method that will indicate the bond strength between the base and the electrodeposited metal.

"Electrodeposits may show no bond weakness during the normal finishing operations such as buffing, burnishing, or brushing, yet will blister or peel from the base after the article is in use a short time, or if it has been exposed to corroding conditions. On many articles the only test for good bond that is applied is the finishing operations; this test is not adequate.

"There are tests, such as deformation tests, that can be made, like flexing or bending to the breaking point, using an Erichsen machine, Brinell testing machine, or similar methods; all such tests destroy the piece tested.

"There are more positive tests such as the hammer and chisel tests or modifications of this method; like the alligator wrench, that can be used on heavy deposits (.01" and up). Test methods such as apply positive pressure to separate the deposited metal from the base in most cases will also destroy the piece tested, but such methods are useful for checking plating procedure that give best adhesion for a given metal, and for studying the various factors that affect the bond strength. The Ollard methods and the Micro-Adhesion method (which is a modification of the Ollard method) are the only methods so

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far as I know that express the bond strength in terms of lb. per sq. inch.

"In the case of the Ollard method a specially prepared piece of metal is plated, then tested for adhesion. In using the Micro-Adhesion method tests can be made on a section taken from a production run item.

"Another method is the can opener type of test. This method also requires the plating of a prepared piece of plated metal so that one end has no bond to the base. This loose end is inserted in and rolled up on the 'can opener' so that pressure can be applied to separate the deposited metal from the base. This method can be used to determine relative bond strength for various plating procedures, but it is difficult to express this in terms of lb. per sq. inch. It can be used on samples from production run items; but it would destroy the finish, making refinishing and replating necessary.

"The black light test and modifications of it is used to test bond, but only indicates no bond at open edges where oil can penetrate between the deposited metal and the base. The deposited metal may blister badly but unless there is a break in the deposited metal so that the oil can penetrate between the deposited metal and the base, there is no bad bond indication by this test.

"X-ray is used in a test method for bond but I doubt if it could determine bond strength. It does no doubt show areas where there is no bond.

"The hammer and chisel test method and modifications of it can be used on heavy deposits (0.1" and up). There are three ways this method can be used to check the bond on items like bearings where only one side is plated:

"A. Plate the bearing so that the silver plates up above the edge of the base to allow the application of the hammer and chisel test.

"B. Allow extra stock in the steel shell so that when the edge is distorted by the chisel test there is still enough stock to finish to required dimensions after distorted area is removed.

"C. Where A or B cannot be applied, apply the chisel test on a definite percentage of each lot plated and take the scrap penalty.

"Heating after plating is sometimes suggested as a test for bond strength but it is not satisfactory because there are conditions where heating will cause blistering of the deposit. This blistering occurs because moisture has been sealed in by plating over moist dirt or rust or deep pits in the base. When heat is applied the plate is 'blown up.' Extremely poor bond will, under some conditions, cause blistering on heating. In general, heating after plating improves the bond strength of most deposited metals where diffusion occurs, should the bond be weak as plated.

"Experiments have been made by using what is called a Supersonic Reflectroscope to check the bond of electrodeposits. So far as I know, results have not been very promising. In this test, supersonic vibrations are reflected from a transmitter through the metal under observation, and indicates any discontinuities in or between any of the layers of metal under test but does not indicate bond strength. A weak bond may not show discontinuities but if the bond blistered slightly so as to cause a void between the base and the deposit this would be detected by the Supersonic Reflectroscope."

QUALITATIVE and SEMI-QUANTITATIVE METHODS

Bending and Twisting Tests

The first recorded tests for adhesion so far located were described by C. F. Burgess in an article[1] published in 1905 on the properties of zinc coatings. The following is quoted from this paper:

"The toughness and strength of the coatings were tested by passing various samples between iron rollers. In some cases the coatings were so brittle as to be cracked off in scales by this treatment, and in other cases the zinc seemed to be pressed into the iron, and to preserve a perfectly continuous coating. By bending such samples at a sharp angle after having been compressed by the rollers, the coatings could in most cases be peeled off. Such coatings were then examined for brittleness, ductility and porosity.

"Another test consisted in determining the degree to which galvanized iron could be bent before developing cracks in the zinc. This was done by placing a strip of the iron in a device especially constructed for the purpose by means of which the

amount of deflection that is required to produce cracks in the coating can be measured, the cracks being detected by means of a microscope."

The next mention (so far located) of tests for adhesion is in an article[3] published in 1911 by Andrew McWilliam and W. R. Barclay on the adhesion of electrodeposited silver on German silver. The research was instituted because of the return of several silver plated articles from various sources. It appears that the tests previously relied upon were the regular finishing and burnishing processes of production. After some preliminary work, the simple bending test was adopted as indicated in the following quotation:

"With these points in view, several preliminary tests were made with the apparatus available, and finally it was decided to adopt the test which had first appealed to the authors, namely, a simple cold bending test. One part of the sample is gripped in a vice and the free part is bent to and fro until it breaks off. It is advisable that the angle of the bend should be about a right angle in order to ensure that the deposit and the basis metal get sufficient movement relative to one another. It will be evident that this test is an extremely severe one, and the silver must be parted from its base, for the silver on the outside of the bend must move a greater distance than the base metal, and on the inside of the return bend a less distance."

It is interesting to note that in the above quotation it is recognized that a definite procedure for the bend test is desirable.

In 1919 an article[8] appeared by W. A. MacFadyen. The objective was to find a suitable method for obtaining thick and adherent deposits of iron on steel in order to build up worn steel parts. The bending test previously described was further modified such that the plated strip was bent backward and forward through an angle of 180°. In addition to the bend test, four new tests were introduced. These are given in the following quotation from the article:

"In the concentration experiments the adhesion of the deposits was tested by gripping the steel strip with its deposit in a vice, and bending it backwards and forwards through an angle of 180 degrees until the strip broke. The quality of adhesion was then judged, as in the best cases the deposit broke off flush with the steel basis, whilst in the worse it split off to a greater or less extent before the steel snapped.

"1. Squeezing Test: — The tube was squeezed in a vice until the shorter diameter was about half the original diameter, sometimes until the tube was squeezed flat. This was found to be very stringent, nearly all the deposits beginning to flake off where gripped. The results depend partly on the original thickness of the steel tubing, since a thin walled tube can be squeezed much more easily than a thick one, and the results are consequently better in the former case.

"2. Impact Test: — The tube was struck repeated heavy glancing blows with a hammer having a one-pound head. This seems to be a good test, the deposits varying a good deal in results.

"3. Sawing Test: — The tube was held in a vice, and a piece was then sawn off the end with a hack-saw. The quality of adhesion appeared to be inversely proportional to the thickness of the deposit, for thicknesses up to about 0.02 inch, but really thick deposits, say 0.15 inch, always stood the test well.

"4. Grinding Test: — The deposit was ground through by a dry emery wheel 6½ inch in diameter, rotating at a speed of 1400 revolutions per minute. Most deposits stood this test very well, though the top and bottom of the cathodes often stood it badly, this often being undoubtedly due to handling the cathode with the fingers after coppering."

In this country, J. D. Alley was also working upon the electrodeposition of iron for building up worn parts. In his discussion of a paper[9] by E. A. Vuilleumier on nickel deposition he briefly describes three methods he used to test adhesion. One is the familiar bend test, but the other two appear to be new up to this time; one is somewhat similar to present day quantitative tests. His statements follow:

"In the second test we took a piece of cold rolled steel about an inch in thickness and had a hole drilled in it. We plated on our rods and ground them accurately to size; the hole in the cold rolled steel

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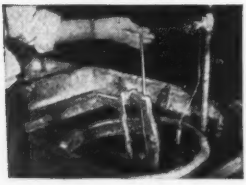

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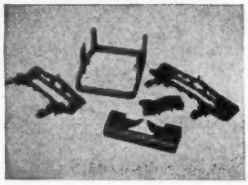

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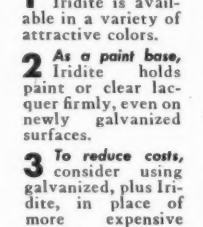

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block was made a half mil smaller than the rods, and we pressed the rods through this hole and back, and there were no signs of stripping of the plated material from the parent metal.

"In the third test we heated the iron after the material had been plated on, and forged it. We could not get it to crack or break off, and in the microphotographs of it that were taken, we could not see a dividing line between the plated-on material and the original cold rolled steel, except in the difference in the appearance of the two metals."

The first indication of an attempt to standardize adhesion tests is contained in the abstract[18] of a report by H. A. Stacey in 1926. The abstract follows:

"In an attempt to draw up a specification for galvanized sheet steel, the sub-committee of the Federal Specifications Board made a series of tests to obtain reliable information of the following points: (1) the minimum mandrel thickness, expressed in terms of the thickness of the sheet tested, over which sheets of different weights of coating can be bent 130° without serious damage to the coating; (2) the minimum radius of curvature on the inside of the angle of 90° bends in such material; (3) the effect of double seaming on the coating; (4) uniformity in the thickness of coating over a sheet, particularly as related to the results of bend tests.

"The material and test procedures are described with diagrams and are discussed. Stripping and bending tests data for a large number of 16 and 22 gauge sheets of different coatings are given with summary diagrams, also close-ups of sheets after bending, and a proposed clause to cover bend properties."

In an article[22] by G. B. Brook and G. H. Stott on testing of electrodeposits on aluminum the authors propose a real attempt at standardization of the bend test. It should possibly be designated as the twist variation of the bend test. This article together with the discussions contains so much valuable material that large sections of it are quoted here:

"Simple workshop tests as a rule leave much to be desired; such a 'bending test' is adopted by Work; others, in which the material is sheared in an endeavor to promote the fracture of the deposit from the underlying metal, and abrasion tests, are all, by their very nature, unsatisfactory, in that they are not carried out under controlled conditions, and hence are not truly comparable. The authors sought to evolve a test in which each part was standardized — namely, the length and width of the strip, the rate at which the bending was carried out, absence of irregularity in the bending movement — and, at the same time, sufficiently drastic to disclose the weakness or poor adhesion of the deposit. One factor, which could not be controlled, has to be admitted, although this was not a serious one in the particular specimens on which the test was done: manifestly, for the same diameter rod around which the test-piece was twisted, the same gauge of sheet should be used for the test-pieces. This certainly should apply to substantially thicker material than that which was represented by these particular samples, but we do not think that such variations in thickness as obtained would materially affect the results.

"The test consists in twisting at a uniform rate of standard strip 8 in. by ½ in. around a ½ in. bar, the bar (B) being held in the chuck of a precision lathe rotating at 20 r.p.m. The test strip is inserted in the slot (A) (Fig. 9, Plate XIII), (*our Fig. 7*), which was so cut as to allow

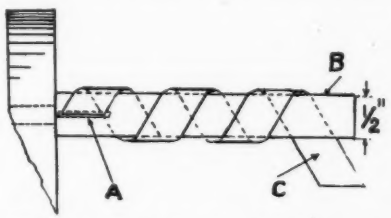

Fig. 7. Mandrel for twisting test (electrodeposits on aluminum).

the strip to emerge at an angle of 60°, the edge of the slot being rounded off to prevent fracture of the test strip; the other end of the strip (C) is held firmly in pliers, and the lathe started, the resulting strip being bent into the form shown in Plates VIII and IX (*our Fig. 8*).

"On the whole, the test worked excellently, but should it be adopted as a standard method further investigation is required, and standards set up for pure aluminum and alloys of different kinds.

"It would also be desirable to bring all

materials, before testing, to one temper, always provided the temperature employed is not such as would tend to promote blistering or peeling of the deposit."

The published discussion of this paper contains several highly pertinent and valuable remarks some of which are quoted below:

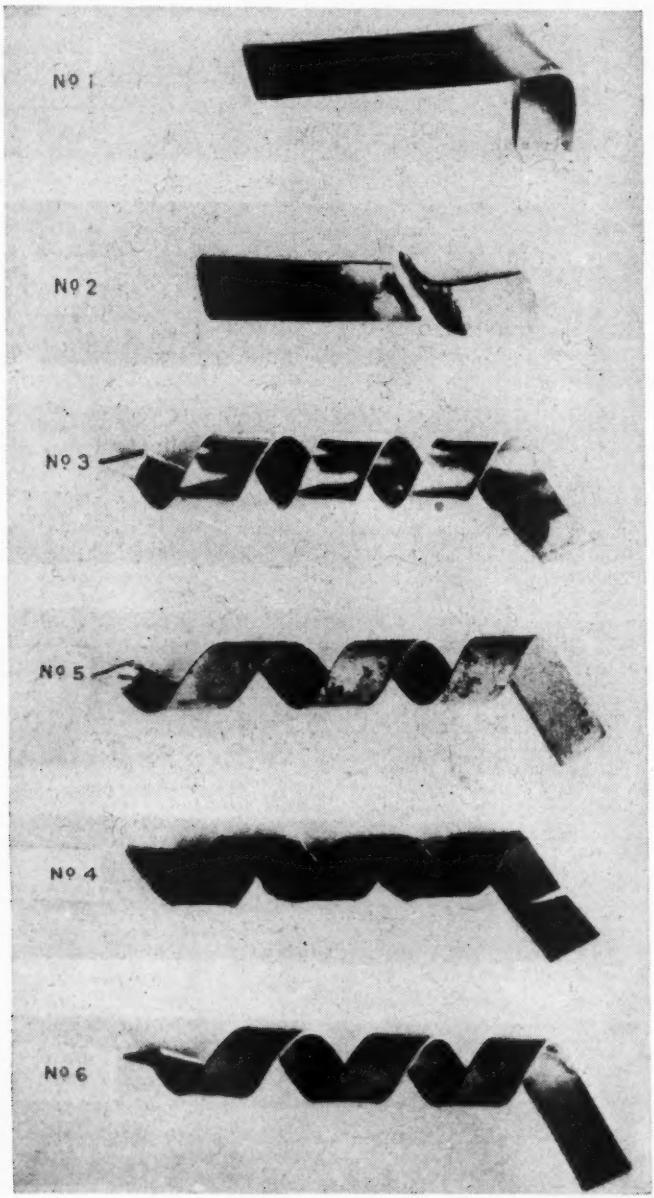

Fig. 8. Plated strips bent with mandrel shown in Fig. 7.

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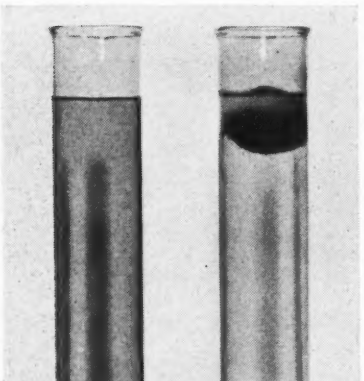

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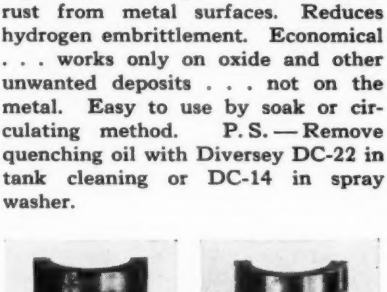

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"*Prof. D. Hanson,* Prof. of Metallurgy, The University, Birmingham, D.Sc. (Vice-President): The twisting test is a very severe test; six out of twelve samples withstood it successfully. Whether a coating would stand a test of this kind depends partly on the amount of internal stress.

"*Frank Mason,* Stainless Plating, Ltd., Sheffield: While the methods formulated and explained in this paper will prove an efficient test for the adhesion and porosity of electrodeposits upon most metals, it is problematical whether this all-important and distinctly characteristic tendency of the metal to strip or lift in blisters when deposited on aluminum will be revealed by the procedure adopted. I trust that further investigations will be carried out in this very extensive field.

"*Mr. H. Sutton,* Chief Metallurgist, Royal Aircraft Establishment, South Farnsborough; and Mr. A. J. Sidery, Metallurgist, Royal Aircraft Establishment, South Farnsborough: Turning to the authors' test for adhesion of the deposits, we observe that the thickness of strip was not standardized. We would suggest that the radius of bending should be expressed as a multiple of the thickness of the sheet, thus rendering the test applicable to any thickness of sheet.

"*Dr. Harold K. Work,* Research Bureau, Aluminum Co. of America, Buffalo, N. Y.: The authors have undertaken a most difficult problem — namely, to measure accurately the adhesion of electrodeposits to a basis metal. They state that simple workshop tests such as bending (which I used in an investigation to which they referred) leave much to be desired. I agree with the authors in this. However, the substitution of a more standardized and more complicated test would only be justified if the simple bending test did not accurately reproduce its results, or if the standardized test were more accurately a measure of adhesion. It has been my experience that such simple tests can be reproduced, provided, that certain conditions are kept constant. These are the thickness, temper, and other physical properties of the metal plated upon, and the thickness and physical properties of the coating — the same properties which must be constant in the twisting test.

"As to keeping the temper of the basis metal constant, that is not advisable, because the quality of the plate varies with the temper of the metal plated on. This makes it impossible to bring the metal to one temper before plating. It is equally useless to bring the metal to one temper after plating as the authors suggest, because this process would affect the adhesion.

"The only way in which the twisting test could be made valuable quantitatively would be to prepare a test on a given coating for every temper of every alloy that is commercially used. This is impracticable, considering the number of alloys that are now on the market. Neither does this procedure apply to castings. Even if these careful tests were made they would be useless in measuring true adhesion unless the physical properties of the plate were kept constant.

"It is my opinion that the most serious objection to the simple bending test applies equally to the standardized twisting test; neither actually measures the true adhesion of the coating. The experiments of the authors bear this out. It will be noted that their sample B, which is copper coated, exhibits 'good adhesion' while sample A fails, due to the application of a nickel layer over the copper. Undoubtedly the true adhesion was poor in both instances, and the added nickel merely set up greater stresses which effected the peeling. These same stresses were undoubtedly responsible for the fracture of the basis metal which the authors reported. The strong nickel layer being on the outside of the twisted specimen would tend to bear the main burden of the tensile stresses. When the nickel due to its low workability cracked under the stresses, it left areas of unprotected aluminum under these cracks with other areas of aluminum between reinforced by a nickel sheath. Naturally, with this localization of the stresses, the aluminum gave way.

"*The Authors* (in reply to correspondence): One of the authors in his reply at the meeting, dealt with the suggestion made by Mr. Mason as to a burnishing test furnishing a means of discovering an insecure deposit. From a long experience one can answer the suggestion both in the affirmative and the negative, but as

in the majority of cases the basis metal is either etched deeply or actually rendered extremely rough by sand-blasting, the burnishing test suggested by Mr. Mason would, in this case, not be possible.

"We recognize the fact that if the bending test is to be standardized, consideration of the thickness of the material would have to be taken into account, and we are obliged for the valuable suggestion put forward by Messrs. Sutton and Sidery — viz. to express the radius of bending as a multiple of the thickness of the sheet. We would also point out that the thickness of the deposited metal film was actually determined chemically, so that the point raised by Messrs. Sutton and Sidery is satisfied.

"We much appreciate Dr. Work's contribution. The statement in his first paragraph appears to be somewhat contradictory — he first agrees that simple workshop tests leave much to be desired, and then claims that such workshop tests can be reproduced. It is actually the variation which is always present in the so-called workshop test that led us to call attention to the need of standardization — e.g., it is conceivable that in the simplest of bending tests the radius and speed with which the bend is made may vary where, as is often the case, the test strip is bent between the noses of two pliers. Whilst recognizing the important points raised by Dr. Work regarding thickness, temper, and the physical properties of the deposit, all of which we dealt with in our paper, it has to be admitted that such variables demand equal consideration in a simple and uncontrolled bending test.

"In putting forward this test, we recognized that it was not intended to be the final form, but rather a guide to those who had made tests their special study.

"We recognized and admitted in the paper the difficulty with regard to so treating the test specimens as to bring them to the same temper; not particularly from the point of view of the test itself, but recognizing the fact that the articles themselves, of which the test-piece only formed a part, could not be so annealed. It would be manifestly unfair to carry out a test under conditions other than those which the article actually in use would be called upon to sustain."

In 1932, A. W. Hothersall[37] made an exhaustive study of adhesion measurements. He describes improvements in the peeling tests frequently used, and his variant of the bend test is very interesting. His remarks on these tests follow. His study of other tests will be presented later.

"Qualitative Tests: A nickel deposit 0.02 inch in thickness was formed on both sides of a suitably prepared brass sheet about 2 inches square, and in most cases not less than about 0.03 inch in thickness. The deposit was then tested in the manner illustrated in Fig. 1 (*our Fig. 9*) and comprising the following stages: (1) The edges of the composite plate were sawn off so as to expose the brass and the cut edges filed smooth. (2) Attempts were made to detach the deposit from the brass by means of a hammer and chisel; if possible, the deposit was turned outwards and flattened in the form of a tongue. (3) The tongue of deposit was gripped with pliers and pulled away from or twisted off the brass. (4) In cases where the deposit could not be readily separated from the brass by means of a chisel, a saw cut was formed in the specimen, which was then gripped in a vice just below the cut and bent over until fracture occurred, when the degree of adhesion could be approximately gauged from the appearance of the fracture — e.g., (5) with coatings not firmly adherent, some degree of separation of the deposit from the brass could be seen at the site of the fracture (in which case further chiselling tests were carried out), or (6) with very strongly adherent coatings there was no sign of separation of the deposit from the brass."

He also makes an attempt to classify degrees of adhesion based upon qualitative measurements as follows:

"Slightly Adherent — Only a very slight degree of resistance was experienced in detaching the deposit which, when separated as shown at (2) of Fig. 1 (*our Fig. 9*), could be pulled off with the fingers.

"Moderately Adherent — Some degree of resistance was experienced in attempting to pull the deposit off the brass, and the pliers had to be firmly gripped. Detachment was, however, effected fairly readily by means of a direct pull.

(*Continued on page* 1135)

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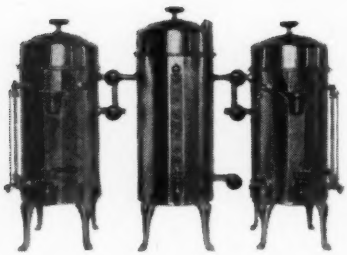

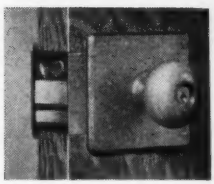

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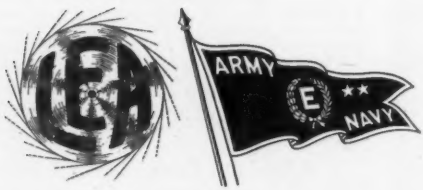

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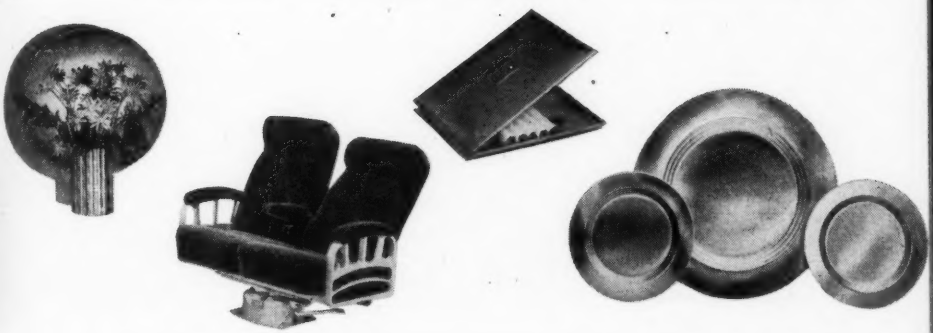

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(*Continued from page* 1130)

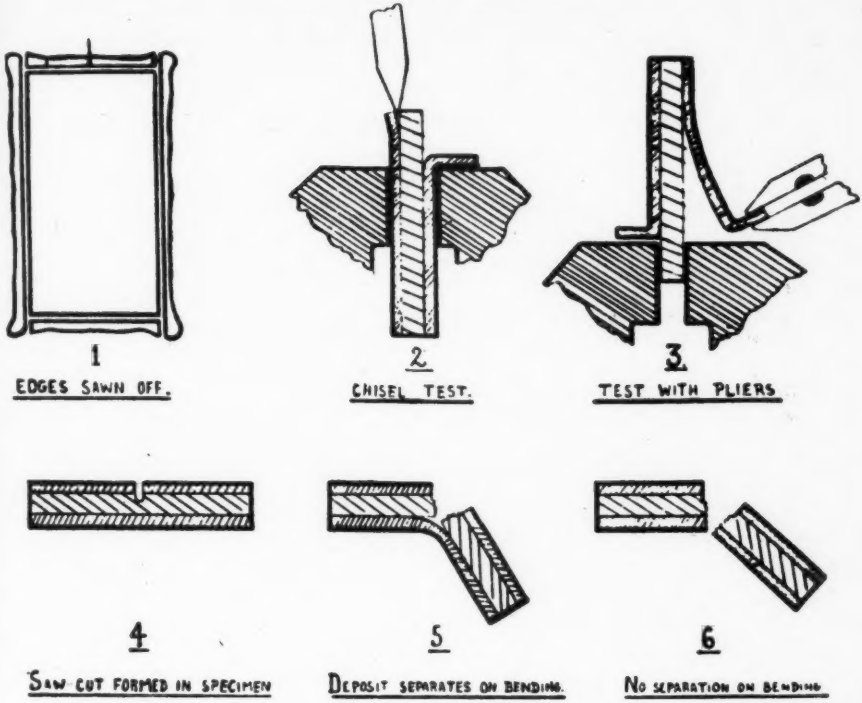


Fig. 9. Qualitative adhesion tests.

"Fairly Strongly Adherent — Vigorous direct pulling with the pliers only succeeded in detaching a small portion of the deposit, but if the deposit could be successfully gripped with the pliers it could be detached by twisting after the manner in which a sardine can is opened. Detachment of the deposit in one piece could, however, be effected by means of the chisel.

"Strongly Adherent — Some separation with the chisel was possible, but only small pieces could be detached as such force had to be used that the chisel cut through either deposit or basis metal.

"Very Strongly Adherent — No separation of the deposit from the basis metal could be effected by any of the methods referred to above."

As pointed out before, the galvanizing profession has made a greater effort to standardize and to consider the bending test in a more quantitative manner than the electroplating profession. This is illustrated in an article by H. Bablick.[27] An attempt is made to consider somewhat quantitatively such factors as bending radius, thickness of the base metal and of the deposit. He states:

"In Fig. 1 (*our Fig. 10*) are shown the conditions for a hot-galvanized coating

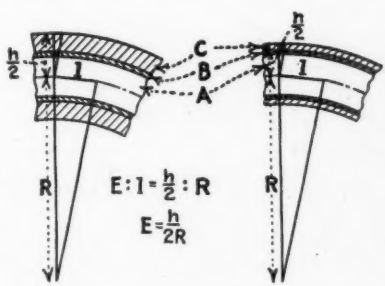


Fig. 10. Elements in bending hot galvanized sheets. A is the iron base, B the iron-zinc alloy layer, C the pure zinc, E the extent of lengthening, R the bending radius, h the total thickness of the galvanized sheet.

when it is bent. There is a great difference in lengthening of the three layers of a hot-galvanized coating. Especially interesting is the lengthening of the outer pure zinc layer, in view of the neutral zone of the iron base. From the calculation given, the lengthening of the pure zinc layer is dependent on the bending radius and on the thickness of the sheet. As the calculation shows that the lengthening $E = h/2R$, it follows that the lengthening becomes greater as the sheet is thicker and the bending smaller."

There is one type of test, several variations of which are being used, that H. Bablick does not consider a test for adhesion. His statement on this point follows and also an illustration is included:

"Of course we can imagine that the danger of the peeling off of the coating increases with the increasing of the lengthening. It must also be stated here that numerous experiments have repeatedly established the fact that, by any lengthening of a galvanized sheet, the coating peels off only when the lengthening of iron base differs from that of the coating.

"If the iron base and zinc coating are lengthened to an equal extent, there is no likelihood of the zinc coating breaking before the iron base. A lengthening after the manner of Fig. 2 (*our Fig. 11*) will, therefore, never result in coatings peeling off. In the case of bending, the lengthening of the iron base differs from that of the zinc coating, so that the two layers are stretched side by side and concurrently to different lengthenings. The result is that they are forced apart, as shown in Fig. 3 (*our Fig. 12*).

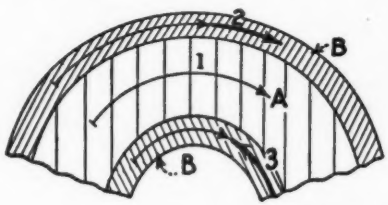


Fig. 12. Unequal lengthening of the base and coating caused by bending leads to peeling. A is the base metal, B the zinc coating, 1 the lengthening of the neutral zone, 2 and 3 the differing lengthenings of the two zinc layers.

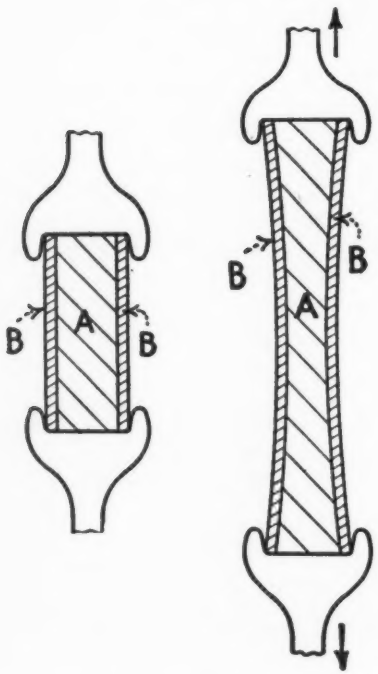


Fig. 11. Straight lengthening of a coated sheet changes condition from that at left to that at right, without peeling of the coating. A is the iron or steel base, B the layer of zinc.

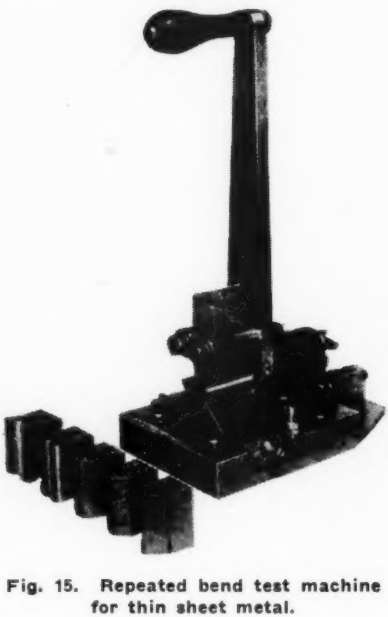
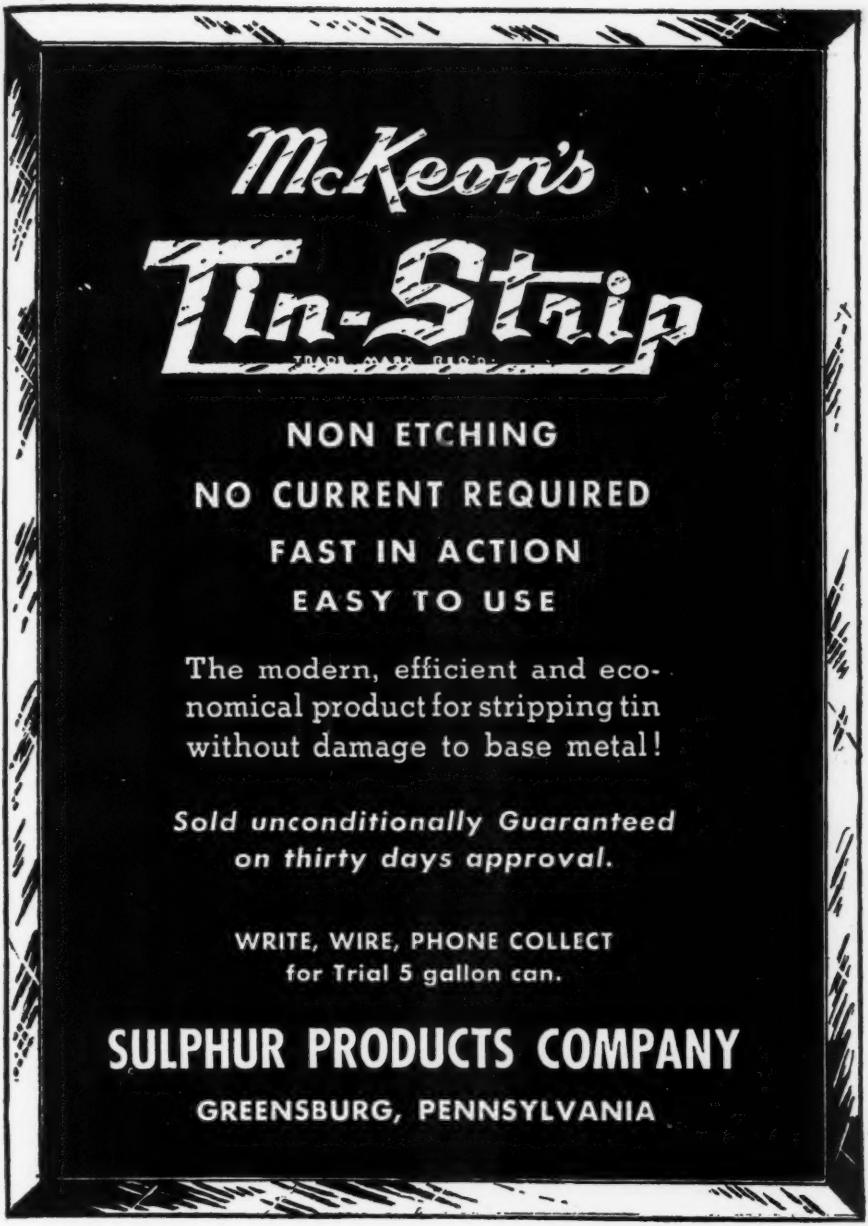


Fig. 15. Repeated bend test machine for thin sheet metal.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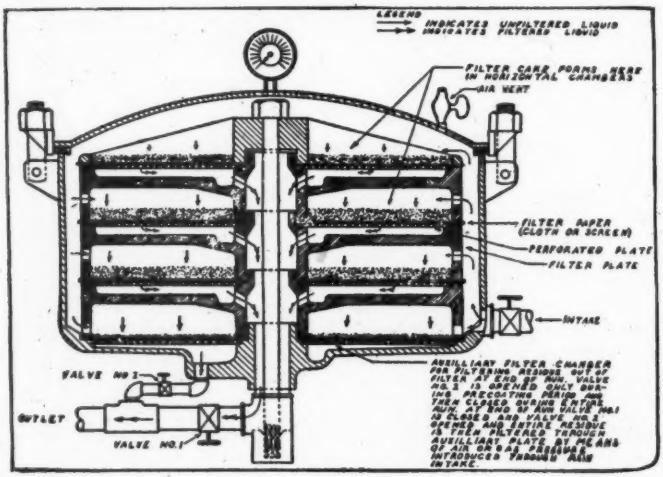

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"This explains the well-known fact that galvanized coatings when heated peel off. We must remember that there is a great difference between the expansion qualities of iron and zinc. Under ordinary conditions the expanding of zinc is nearly twice that of iron. Thus there is a difference in the lengthening of the two main layers with the result — a separation and, further, the peeling off of the zinc coating."

An attempt at a standardized procedure, adopted by some of the most responsible groups in the country, is briefly described and well illustrated in this same article by Bablick (Figs. 13 and 14).

Another type of bending machine is recommended by R. L. Templin[70] (Chief Engineer of Tests, Aluminum Co. of America) in which some attempt is made at standardization. Samples of a definite width may be used, the angle could be made 90° or 180°, and the bend could be made over mandrels of various diameters. The rate of bending could also be standardized. The radius of bending could be made to have a definite relation to the thickness of the sample. The results could be expressed in different terms as desired. A picture of this device is given in Fig. 15. (page 1136)

One of the most recent bend testing machines is that described by R. E. Wheeler[89] in 1938. It was designed for testing organic finishes but might be used equally well for electrodeposits. The following is a discussion of this machine and its opera-

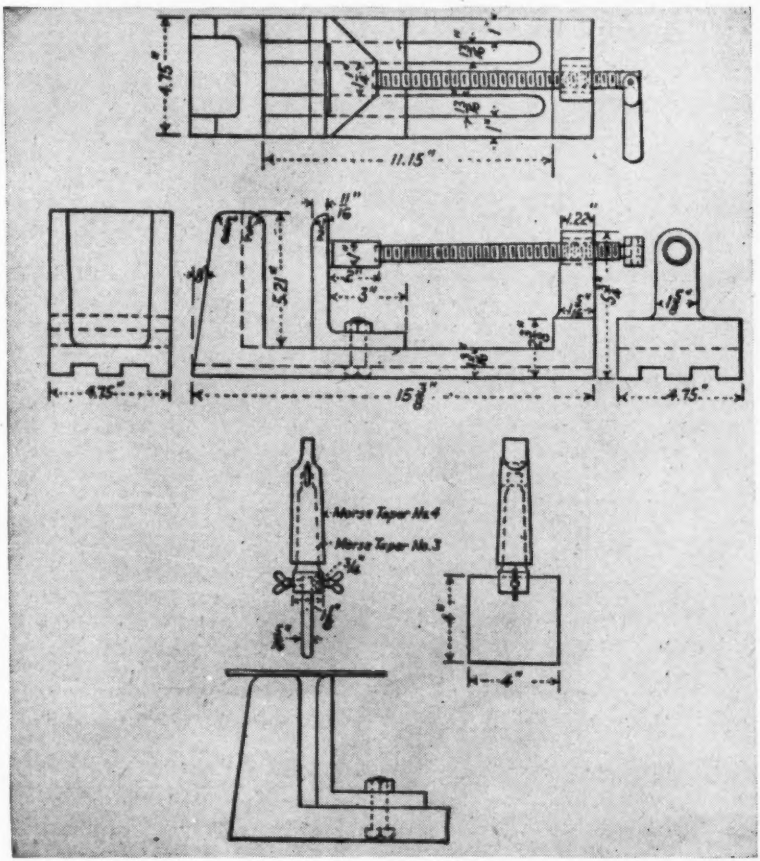

Fig. 13. Laboratory apparatus to test bending quality used by Washington Navy Yard.

tion in Wheeler's own words:

"Testing an organic finish for adhesion by bending over mandrels of various diameters and noting the smallest diameter which ruptures the film has been used as a means of comparing finishes for many years. This is a rather tedious procedure since it requires several different bending operations. Ordinarily, this means that several panels must be prepared or that one panel must be completely ruined to perform the test and additional panels must be made if further tests are to be run. A bend tester on which a panel can be passed over several different radii at the same time and yet preserve the panel for further tests is illustrated in Figures 10, 11 and 12 (*our Figs. 16, 17 and 18*).

"Figure 10 (*our Fig. 16*) shows a general view of the bend tester showing the roller which gives a true rolling action to the bend and also the template for cutting the panels and a panel as cut and finished. The template has slots cut in it approximately 1 in. apart to correspond to the bending blocks shown in Figure 11 (*our*

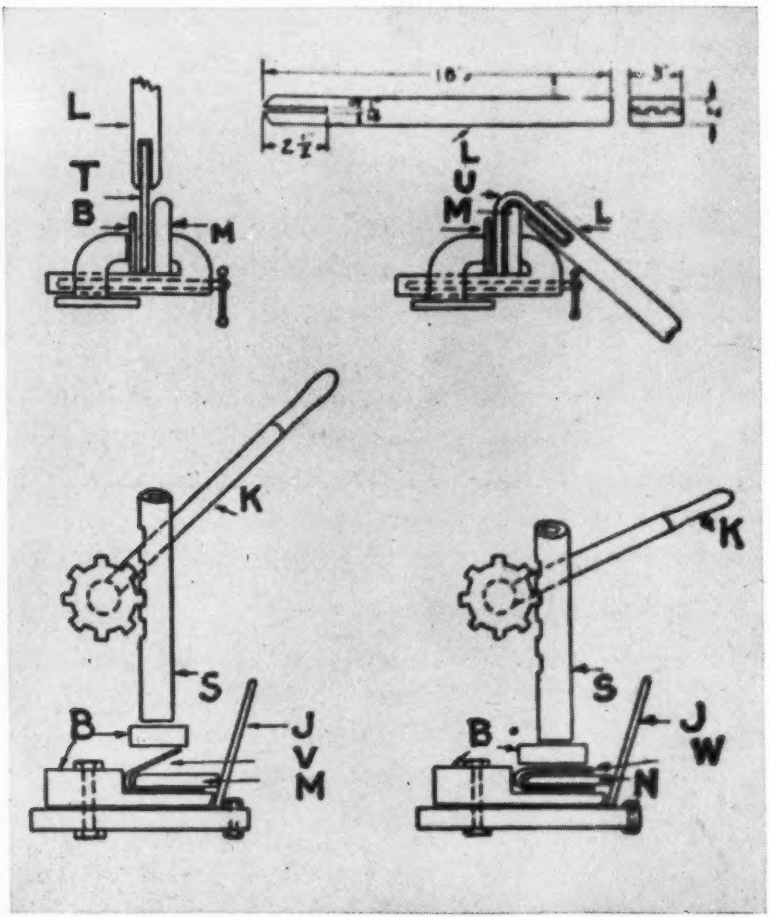

Fig. 14. Laboratory apparatus to test bending quality used by New York Navy Yard, National Bureau of Standards and New Jersey Zinc Company. T is the test piece ready for bending, U same after bending to 135 deg., V same ready for compression over 2-in. mandrel M, W same ready for 1.75-in. mandrel N, L lever for first bend, K operating lever for spindle S, J lever to hold mandrel up to its work, B blocks of wood or fibre.

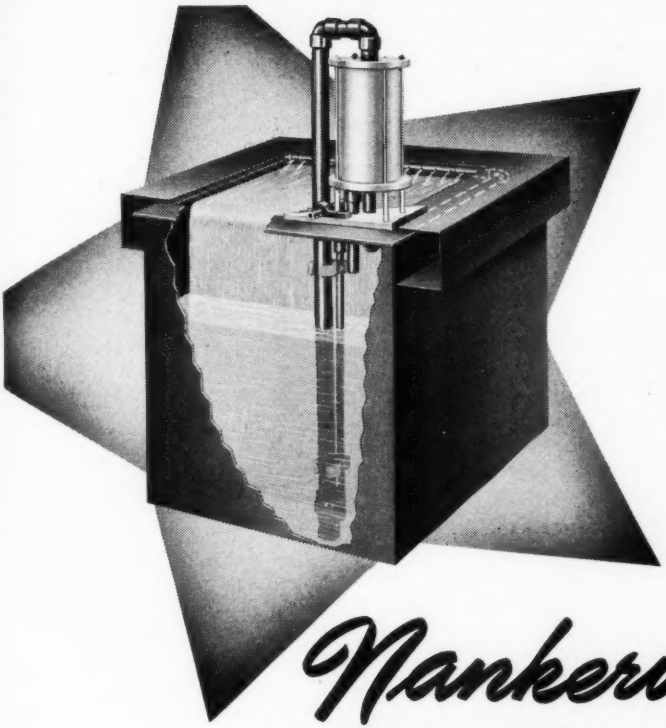

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Fig. 17). There are also two holes drilled in each side of the plate so that the panels can be bolted together while they are being sawed. The template is of necessity case hardened. The panels used measure 4¾ in. × 6 inches.

"When it is desired to prepare panels for testing, thin sheet steel is cut to the required size. Eight or ten panels are then clamped to the template and the two holes are drilled. A nut and bolt is then inserted in each hole to hold the panels together and a clamp is placed on each side of the slot to be sawed. The entire assembly is clamped in a vise and the four slots sawed out. The panel is coated with the material it is desired to test and is then fastened to the tester by means of a bar. Holes are drilled in this bar which correspond to the holes in the test panel and also the bending blocks. Two bolts which pass through the bar and the panel and which thread into the bending blocks are used to hold the panel in position while a test is being made.

"Figure 11 (*our Fig. 17*) shows a front view of the bending blocks which are ground to 90° and the following radii: ½ in., ¼ in., ⅛ in., 1/16 in. After inserting the panel as described above, the key which holds the handle in the up position is removed and the handle is then pressed

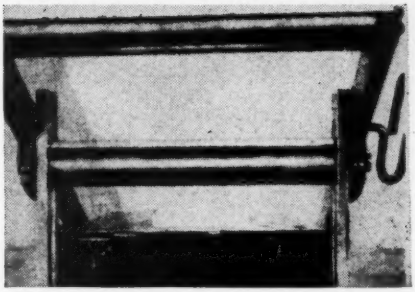


Fig. 17. Front view of bending blocks ground to various radii.

downward. This action forces the roller to roll over the faces of the bending blocks with enough clearance being allowed for the panel.

"A sample panel after the bending operations is shown in Fig. 12 (*our Fig. 18*). The panel can be removed for inspection and the rupturing radius recorded. The bent end can then be cut off or the panel used as it is for additional tests. In constructing this type of tester, one must be sure that the bars which support the roller and handle are long enough so that the roller will describe nearly a straight arc across the faces of the bending blocks on the downward stroke."

During recent years there has been much greater attention given to adhesion. Sev-

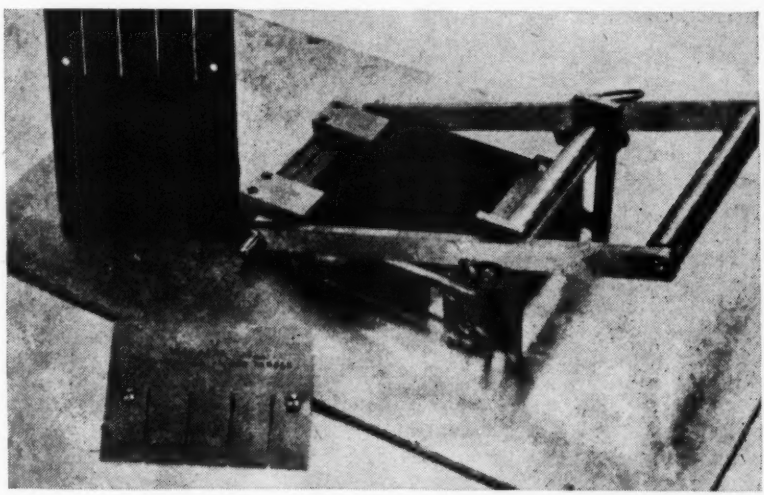


Fig. 16. Bend test machine on which panel can be passed over several different radii simultaneously. Note roller, template for cutting panels, and cut panels.

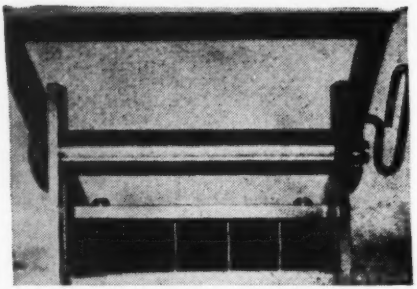


Fig. 18. Panel in bend test machine following bend testing operation.

eral times hammering has been mentioned as an extra severe test. In it the sample is first bent completely back upon itself, and then the bend is hammered down. In discussing the article by F. C. Mathers and L. L. Gilbertson[86], G. B. Hogaboom, Jr. remarks:

"There is no good method for testing the adherence of deposits on experimental steel plates. The simplest test I have found is to bend the plate at 180° and hammer it flat. If the deposit stands that hammering at the point of curvature, you may be relatively certain that it is adherent."

Bending and twisting tests of some nature are by far the most commonly used for testing adhesion, especially for thin deposits, but to a considerable degree even for thick deposits such as used on bearings. Wherever the nature of the tests is mentioned in the literature, some kind of a bend test is almost universally included. It is equally true that a bending or twisting test is included by those who have sent in private communications referred to in a later article.

Burnishing, Buffing and Abrasion Tests

The literature does not contain much information on this type of test. The first mention so far discovered is by C. F. Burgess[1] in 1905. He states:

"The method employed for testing the resistance to abrasion consisted in placing samples of galvanizing in a porcelain-lined tumbling barrel, together with quartz sand. After the barrel had been turning at a slow rate for a number of days, weight determination showed the amount of zinc which was removed per unit area of surface."

The method is again mentioned in an article[3] by Andrew McWilliam and W. R. Barclay in 1911. They state:

"In order to correct a misapprehension which might arise, it may be necessary to point out that no attempt is here made to discuss the ordinary causes of the 'stripping' or 'peeling' or 'blistering' of electrodeposited silver from the base metal during processes of manufacture — because articles so treated rarely pass from the hands of reputable manufacturers, the faults being revealed during the subsequent finishing and burnishing process, it being well known that if the slightest trace of grease or oxide remain on the surface of the base metal, the electrodeposited silver will blister under the pressure of the steel burnishing tools used in finishing."

From these remarks and others the inference is clear that burnishing operations during the regular manufacturing process had been generally accepted by the silver platers up to that time as a satisfactory test for adhesion. From more recent remarks it is evident that it is still generally considered by them as satisfactory. Private correspondence and interviews during the progress of this research show that some variant of this type of method is extensively used by many platers at the present time.

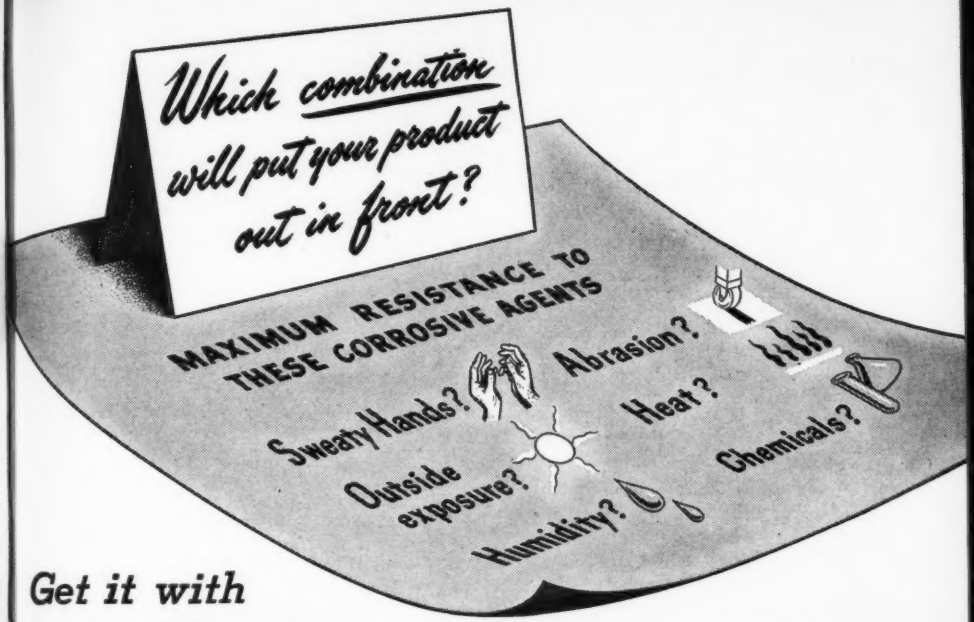
S. Wernick[62] states:

"Burnishing Test: It shall be possible to burnish the deposit with a blunt instrument and this operation shall in no way result in the flaking or blistering of the deposit."

Again, in a later article[109] Wernick states:

"Inadequate adhesion to the basis metal may not be immediately apparent, but it can be readily detected by local burnishing of the plated surface. The friction engendered soon results in the development of a gap between the deposit and basis metal. This method of detecting non-adhesion constitutes a useful workshop test of this property. Local non-adhesion quite commonly manifests itself by the appearance of circular mounds, termed blisters by platers."

C. F. Bonilla[72] published an article on heavy nickel and chromium deposits, in which he makes the statement:



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"I term inadequate adhesion any peeling on vigorous buffing or on rubbing strongly on the plated surface with a hard blunt edge such as worn screw-driver."

B. Egeberg and N. E. Promisel[77] state:

"Burnishing: If, at twenty-five pounds pressure, the burnishing tool produces no lifting of the plate (blisters), the adhesion is generally satisfactory."

A. Hirsch[82] makes the statement:

"A barrel burnisher (16x30" diameter, 27 r.p.m.) containing 900 lbs. of 7/32" steel diagonals was used to test adhesion of the nickel deposit. In this test deposits of poor adhesion would 'shell' off the base metal immediately when the burnishing started, while good deposits would burnish indefinitely without 'shelling' of the deposit."

Donald Wood, in an article[90] on nickel plating on stainless steel, calls attention to the use of a test "equivalent to ball burnishing."

Ball burnishing is frequently used for polishing, but at the same time it tests adhesion also. E. G. West[97] has the following to say:

"Electrodeposits are polished by ball burnishing to a higher degree of lustre than is possible by mopping (*'buffing' in U. S.*). Further, the cold working by the balls results in slight hardening and also acts as a ready test for adhesion. This method is particularly useful for precious metal deposits and for the softer coatings, although matte chromium deposits can also be treated."

P. J. LoPresti[127] makes the following remarks:

"Samples were also barrel-burnished for one hour in a small wooden hexagonal barrel with a load of ⅛" steel balls weighing 30 lbs. using a standard soap as lubricant. Here, again, the silverplate over a phosphate coat was as adherent as the standard silverplate."

In private correspondence and interviews it is evident that this method is in fairly general use today. There is the possibility that a machine might be constructed in which are standardized various factors such as pressure, surface area of contact, area burnished, nature of burnishing tool, speed of operation, etc., and which could give rough quantitative information on adhesion. The method would be usable for only relatively thin deposits.

Impact or Hammering Tests

Impact or hammering tests for adhesion were among the first to be used. The first suggestion that such a test be used, was made by C. H. Proctor[7] in 1916. He states:

"The *zinc* deposit apparently becomes impregnated or alloyed with the steel and withstands the severest bending tests and can be hammered completely into the steel itself. Experiments made with temperatures up to 750 to 800 degrees F. have apparently no effect upon the deposit."

The same year M. W. Baldwin[6] in a paper on plating of aluminum remarked as follows:

"It is then nickel plated in the usual manner. The plating adheres perfectly — when hammered or bent, the deposit will not crack and the metal can be heated to the melting point of aluminum without separation of the nickel."

W. A. MacFadyen has an article[8] in 1920 dealing with thick electrodeposits of iron. Several adhesion tests were used, one of which is called the "impact test." Concerning this he states:

"The tube was struck repeated heavy glancing blows with a hammer having a one-pound head. This seems to be a good test, the deposits varying a good deal in results."

J. D. Alley[9] described several tests he had used to evaluate the adhesion of thick deposits of iron, among them a forging test:

"In the third test we heated the iron after the material had been plated on, and forged it. We could not get it to crack or break off, and in the microphotographs of it that were taken, we could not see a dividing line between the plated-on material and the original cold rolled steel, except the difference in the appearance of the two metals."

R. J. Piersol[47] describes an impact testing machine which he developed:

"For conditions where thick plates of chromium are deposited on a non-flexible foundation metal, the writer has developed the impact method of testing for adhesion. As shown in Fig. 4 (*our Fig. 19*), the plated specimen A is held in place against

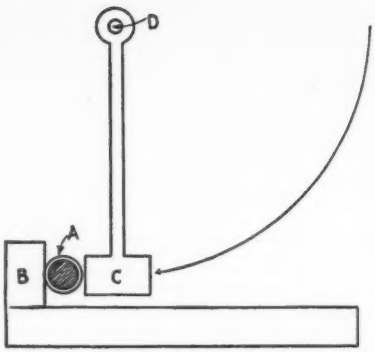


Fig. 19. Impact method of testing adhesion of electrodeposits.

the impact block B. The impact blow is struck by the impact hammer C which drops by pendulum motion with the arm pivoting at D, the hammer being raised by hand to a horizontal position and then permitted to drop by gravity. The number of blows the plate will stand without being knocked off is an index of its adhesive strength."

Another type of impact test, variations of which are in fairly general use, is described by S. G. Clarke in his paper[64] on black lead peroxide coatings:

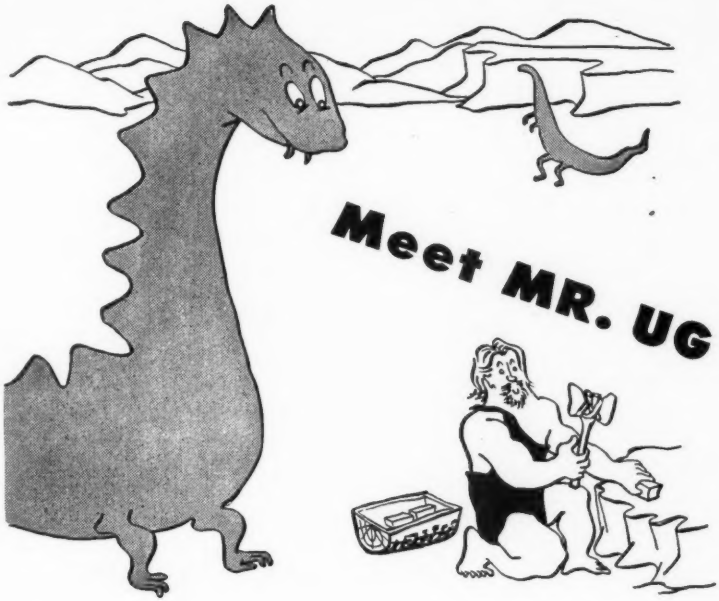
"The deposits were all hard and relatively brittle, but the adhesion varied according to the smoothness of the basis metal. The following tests were carried out on deposits generally of about 0.0005 to 0.001 inch in thickness. Fairly hard scraping with a steel blade or scribe was required to score away the deposit, but when struck, e.g. with an edge of a metal rod, fragments of the coating chipped off. For the purpose of comparing adhesion of different surfaces, blocks carrying the coating were indented by a loaded 5 mm. ball, and the degree of flaking around indentations of similar diameter (about 2.9 mm.) was noted. According to this test, the adhesion on bright rolled steel and polished copper was poor or negligible and considerable flaking occurred. The adhesion on shot-blasted mild steel and rolled copper was better, and there was further improvement with the coating on unpolished electrodeposits (0.0005 in. thick) of copper, zinc or cadmium on steel, little or no flaking being found. The results of bending sheet specimens gave indications that whilst little difference could be detected between coatings deposited at temperature up to 60 degrees C, those formed at 100 degrees C were considerably more brittle and less adherent."

A somewhat quantitative use of the impact tester just discussed is described by R. C. Martin[85]:

"The coated metal panel is inserted in the base of a 32" frame. The panel is placed over a series of hollow metal discs with the coated side of the panel placed downward on the disc. A metal disc contact centered with a ball-bearing device is placed on a cross arm. This arm may be dropped from any point along the 32" scale. The extent of rupture will evaluate resistance to impact. The weight used and distance dropped determine the factor."

The most recent development of an impact tester is described by A. W. Hothersall and C. J. Leadbeater[130]:

"The need for a suitable test for adhesion of electroplated coatings has long been recognized. Most methods so far suggested or used can be classed as: (1) methods in which the article is permanently deformed (bending, hammering, cupping, etc.); and (2) methods in which the coating is scraped, pulled or levered from the base. All of these methods are in some respects unsatisfactory. In the present work three types of test were investigated: (1) The B.N.F. adhesion test, in which a vibrating ball-ended hammer, actuated by a fluctuating magnetic field, bombards the surface and produces blistering of the coatings if poorly adherent; (2) The shot impingement test, in which the surface is bombarded with rounded steel balls; (3) The electrolytic test, in which the component under test is made the cathode in a dilute H_2SO_4 solution. The two latter tests did not prove satisfactory for general application. Method (1) was found to be useful for testing adhesion of non-adherent or weakly adherent coatings. No blistering was obtained when the value of the adhesion measured by another method was only 0.57 tons/sq. in., showing that the method measures only very poor adhesion. Blisters were produced, usually within ten seconds of commencing hammering, in poorly adherent deposits of Cr, Ni, Cu, Cd, Zn, Sn, and Cr over Ni. Deposits were tested on



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"Thicknesses of plate in which blistering was produced varied from 0.0001 to 0.006 in. A hammer-head diameter of 0.06 in. is most serviceable. The test was applied with practical results to 52 times of commercially plated hardware and plumbing fittings. An advantage of the test is that it does not injure the basis metal. Although designed for electroplated coatings, it appears to have possible applications to coatings, both metallic and non-metallic, formed by other methods, e.g., sherardizing and painting."

The B.N.F. adhesion tester, according to W. Canning & Co., Ltd. of Birmingham, England, who manufactures it, has been approved by the British Standards Institute. Since it has created considerable interest also in this country, we reproduce from Canning's Catalogue No. 2581 on the Adhesion Tester Figs. 1-4 as our Figs. 20-23. We also quote from the instructions for the use of this apparatus, which is operated from a 200-230 volt, single phase, 50 cycle A.C. supply, as follows:

"1. The tester can be used in two ways, as illustrated Fig. 3 and Fig. 4 (*our Figs. 22 and 23*). If the article to be

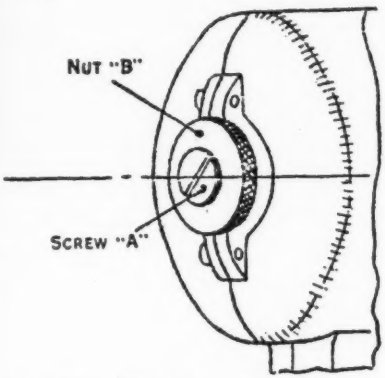

Fig. 21. Vibratory adhesion tester. Adjust screw A to obtain maximum stroke and lock securely hammer-adjusting nut B. Maximum vibration obtained when article is applied to tester.

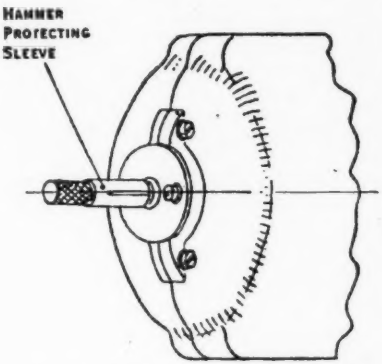

Fig. 20. Vibratory adhesion tester. Pull-off hammer protecting sleeve when using tester.

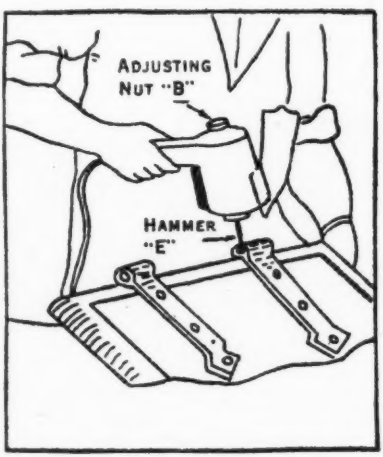

Fig. 22. Vibratory adhesion tester used as portable instrument.

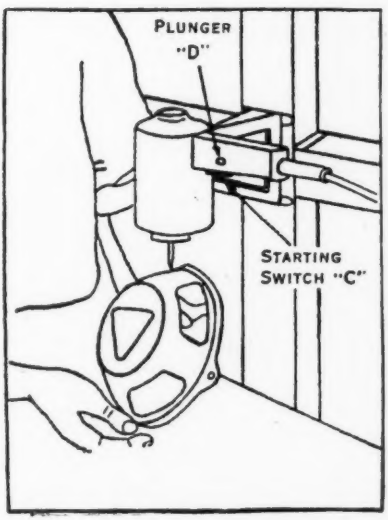

Fig. 23. Vibratory adhesion tester fixed to one type of wall bracket.

tested is heavy it is better to take the adhesion tester to the article, but for rapid operation on light articles it is better to bolt the tester to a bracket.

"2. The hammer blows should usually be normal to the surface but sometimes it is useful by tilting the article to combine normal and oblique blows on the same spot.

"3. The blows of the hammer should be allowed to scatter over a small area, e.g. a circle 1/8" to 3/16" in diameter.

"4. Although it is generally inadvisable to control the action of the hammer, it is possible to regulate the scatter produced by loosely guiding the spring hammer with the fingers. The best effect is obtained by allowing the hammer complete freedom to work at its maximum amplitude which can be judged by the noise produced from the blows.

"5. The test should be discontinued with the blistering or flaking of the coating, which, with non-adherent coatings, usually occurs within ten seconds.

"6. The deposit is considered to have passed the test if no blistering or flaking is produced after testing for one minute."

It should be noted that, to quote Canning, this test "only rejects coatings of negligible adhesion." Its operation and limitations would appear to be much like those of the burnishing tests already discussed.

HARSHAW AWARDED "E" FOR ATOMIC BOMB WORK

A four-star Army-Navy "E" flag was awarded by the Manhattan Engineer District on October 5th to the 640 employees of the Harshaw Chemical Company, Cleveland Plant and Office in recognition of the research, development and production work done by the Company on several different chemicals essential to the atomic bomb.

The award is the only one being given in Ohio by the Manhattan Engineer District and this four-star award to Harshaw is one of only two being awarded in the entire country. Harshaw has been actively engaged in certain phases of research designed to release the energy of the atom in modern warfare before the Manhattan Project had officially taken shape.

Left to right: Joseph Rowe, who accepted "E" pins on behalf of employees; Commander F. L. Ashworth, weaponeer on flight when second atomic bomb fell on Nagasaki; Lt. Col. W. E. Kelley; K. Wurm, President of Union (A. F. of L. Chemical Workers) at Harshaw; Governor F. J. Lausche, Governor of Ohio; H. A. Bradley, President A. F. of L. Chemical Workers Union; Maj General L. R. Groves, Commanding General, Manhattan Engineer District; Major W. G. Akeley; Col. K. D. Nichols, District Engineer, Manhattan Engineer District; Col. John Lansdale, Jr.; C. S. Parke, Vice President in charge of manufacturing at Harshaw who accepted award; Major O. H. Greager; Lt. E. J. Durkin, Jr.; W. J. Harshaw, President of The Harshaw Chemical Company.

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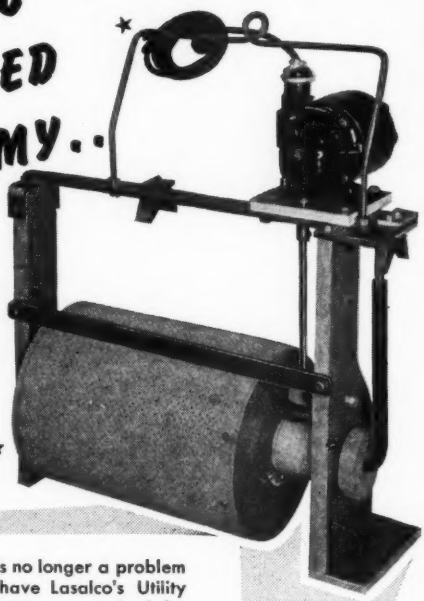

FASTER and more uniform plating is no longer a problem in hundreds of plants who now have Lasalco's Utility Plater. Versatile, to handle any process required for small lots of varying grades and types of material, the Utility Barrel Plater is matched by no other equipment available in its price class.

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INDUSTRY NEWS

Silver Polisher Wanted

For repair work, hollow-ware, etc. to head up department. Permanent, satisfactory arrangements for right man. Agreeable working conditions. Location New York State. Address MR-11B, MONTHLY REVIEW, P.O. Box 168, Jenkintown, Pa.

Chemist or Chemical Engineer Wanted

Large Manufacturer of Buffing Compositions and equipment with excellent experimental facilities wants young graduate chemist or chemical engineer for control, development and service work. Prefer man with some knowledge of polishing methods. Exceptional opportunity for man with ability, ambition and initiative. Midwest location. MR-11A, MONTHLY REVIEW, P.O. Box 168, Jenkintown, Pa.

1945 Oakite Victory Conference

Highlighting each of the 1945 Victory Conferences of the Oakite organization, held in New York and Chicago during October, was a vast exchange of technical information on cleaning, descaling, derusting, degreasing and related operations, particularly as applied to peacetime manufacture of civilian products. In addition to the entire field forces of more than 140 Oakite Technical Service Representatives, these conferences were attended by the staffs of the Mechanical Engineering, Chemical and Research Laboratories of Oakite Products, Inc.

The various discussions were devoted to the determination of the most effective techniques for performing post war production and maintenance cleaning operations on a time-saving, low cost basis. Among the many subjects covered were the war-developed Oakite CrysCoat Process for providing tenacious paint adhesion to ferrous metal surfaces; preparation of aluminum and aluminum alloys for spot welding, Alroking, anodizing and other industrial finishes; surface preparation of basis metals before electroplating; use of Oakite materials in cutting, grinding, drawing, stamping, burnishing, tumbling, etc., and other important subjects.

Of particular interest was the announcement of the newly-developed Oakite-Vapor Cleaning Unit, which will soon be available to industry. Capable of generating steam pressure up to 200 lbs. within 1 to 2 minutes after starting from cold, this unit discharges 60 to 90 gallons of steam cleaning solution per hour at the desired steam pressure up to 200 lbs. Further, continuous operation of two steam guns at the same time is possible with this unit. It is entirely practical for use in a wide variety of industries such as railroads, shipyards and repair basins; garages and service stations; large plants or factories; paper and textile mills; dairies, bakeries, breweries or wherever there is a need for heavy duty steam cleannig.

The information exchanged at the Oakite Victory Conference is freely available to those interested, through the medium of Oakite Technical Field Service Staff.

Harry P. Barrand Joins H-VW-M

Harry P. Barrand has been elected a Vice-President and Director of the Hanson-Van Winkle-Munning Company, Matawan, N. J. Mr. Barrand will devote himself to the financial work of the Company.

Mr. Barrand was, for a number of years, a commercial and financial consultant and advisor, with broad experience with banking, investments and corporation manage-

ment. His experience has included banking and financial work abroad in Europe, South America and Asia.

Ken Huston Joins Rustless Iron & Steel Co.

The Rustless Iron & Steel Company announces the appointment of Kenneth M. Huston to the staff of its Research Division as a Research Chemical Engineer. Mr. Huston will be responsible for the work on corrosion studies, electroplating, electrolytic polishing, as well as coatings and surface finishes on stainless steels.

He is Third Vice-President of the American Electroplaters' Society and President of the Baltimore-Washington Branch. He is a member of the Alpha Chi Sigma fraternity and the American Legion.

Paul R. Cutter Joins H-VW-M

The Hanson-Van Winkle-Munning Co. of Matawan, N. J., announces that Paul R. Cutter has joined their staff as an electrochemist.

Mr. Cutter received his primary and secondary education in Hugoton, Kansas. He received his B.S. in Chemistry from the Panhandle A & M College, Goodwell, Oklahoma, and his M.S. in Physical Chemistry from the Oklahoma A. & M. College, Stillwater, Oklahoma. He has had broad industrial experience in chemical control and research. He previously was Assistant Chief Chemist of Consolidated-Vultee Aircraft Corp., Fort Worth, Texas.

Mr. Cutter will work on special electrochemical processes for the H-VW-M Co.

Nankervis Increases Staff and Offers New Service

The George L. Nankervis Company, 5408 Commonwealth, Detroit, manufacturers and distributors of plating and metal finishing equipment, have again augmented their engineering staff in order to take care of their increased volume of reconversion and new installations of plating and metal finishing plants in the Middle West. With the acquisition of these engineers, the George L. Nankervis Company has extended their services whereby they are now accepting general installation work, including the full contract for complete engineering and installation of plating and metal finish plants.

Mr. M. W. Woodruff, graduate of the University of Michigan with a B.S. in Chemical Engineering, has had extensive experience in metal finishing, production supervision, laboratory control and research. His experience over the past several years

with the Eaton Manufacturing Company of Cleveland, and the Chrysler Corporation, of Detroit, has fitted him well for his new capacity in the Engineering Department of the George L. Nankervis Company.

Mr. W. E. Stadel, a graduate of the University of Michigan with a B.S. in Mechanical Engineering, has had extensive experience in technical supervision of plating, having been associated with Dodge Bros., Wolverine Pump, McGean Chemical, and Chrysler Corp. for the past 20 years.

Dr. Roy E. Heath Heads Wyandotte Chemicals Industrial Sales Department

Dr. Roy E. Heath now heads the Industrial Sales Department of the J. B. Ford Division of Wyandotte Chemicals Corporation. Dr. Heath, who assumes his new duties November 1, will be associated with W. M. Cole, former head of the department, who is retaining his connections with the company for an indefinite period. Mr. Cole is now starting his own business in a field in no way connected with metal cleaning or industrial finishing.

Dr. Heath is a graduate of Albion College and obtained his Ph.D. degree from Western Reserve University where he was a National Carbon Research fellow working in inorganic and electrochemistry. Following one year as lecturer in chemistry at Western Reserve University and two years as instructor in chemistry at the University of Wisconsin, he joined Wyandotte Chemicals Corporation as a market research executive attached to the Sales Department.

Late in 1943, Dr. Heath was granted a leave of absence to join the Metallurgical Laboratory of the University of Chicago to do fundamental chemical research on one phase of the Atomic Bomb Project. He returned to Wyandotte Chemicals Corporation in the fall of 1944.

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FRANK K. SAVAGE

Chairman, Program and Educational Committee

Cathode Polarization in the Deposition of Zinc from Complex Ammino Compounds

A. I. LEVIN. *J. Gen. Chem.* (U.S.S.R.) **14**, 795-801 (1944) (English Summary).

Cathode polarization was measured, and cathode efficiencies determined in the electrodeposition of zinc from complex ammine solutions. The polarization was considerable but caused largely by concentration phenomena. The equilibrium potential of zinc in ammine solutions is also relatively large and becomes more electronegative with rise in concentration of complex-forming compounds.

G. M. KOSOLAPOFF, *Chemical Abstracts*

Chromium-coating of Steel and Range of Application of Gaseous Chromizing

V. I. ARKHAROV. *Bull. acad. sci. U.S.S.R., Classe sci. tech.* **1943**, No. 8, 62-7.

Chromium-coating of steel from the gas phase is discussed. The film obtained consists either of a chromium carbide or of a solid solution of chromium in iron. The type of work for which this coating is recommended is defined.

B. A., *Chemical Abstracts*

Short Cycle Anodizing Used by Boeing Aircraft of Canada, Ltd.

Anon. Steel, **117**, No. 9, 114, 116, 118 (1945).

The processing time for aluminum anodizing has been cut to 20 minutes, using less power and less chromic acid. The new process in some details conforms to U. S. Navy Spec. PT19. Features which differ from this specification are: Solution composition—3 to 5.5% hexavalent chromium, not less than 1.75% free chromic acid; temperature—98°F ± 10° to 20°F; voltage cycle—voltage is increased from zero to 40V in 10 min., held at 40V for 5, stepped up from 40V to 50V in 3 min. and held at 50V for 2 min. Solution is maintained by addition of chromic acid. The cleaning solutions and cycle are given, also a method for stripping splines.

C. W. CARTER

Current Status of the Electropolishing Process

Anon. Steel, **117**, No. 11, 104-106 (1945).

Some producers of consumer articles may find electropolishing a tool for new finishing effects and possible economies. It is particularly useful where mechanical methods are inadequate. It has been found practical as a method of metal removal. The crystals of the base metal are not distorted at the surface and hence better adhesion of plated coatings is claimed. A complete analysis of each application must be made to determine its economy.

C. W. CARTER

The Production of Machinable Chromium Deposits

G. E. GARDAM. *J. Electrodepos. Tech. Soc.* **20**, 69-74 (1945).

A method for the plating of machinable chromium, i.e., chromium having a hard-

ness of not more than about 400 Vickers, has been worked out. A 33 oz. per gal. chromic acid solution was used, with a 100-1 sulfate ratio. The desired deposit was obtained by operating at high temperature with a comparatively low current density. It was found that the current efficiency at high temperatures may be greatly increased by the presence in the solution of trivalent chromium or iron, or aluminum. Beneficial effects on the deposits were obtained by low temperature treatment (300°—480°F) for 1-24 hours. Graphs are presented.

LYMAN B. SPERRY

Chemical Treatment of Aluminum Improves Paint Adherence

C. B. GLEASON. *Am. Machinist* **89**, No. 15, 113 (1945).

The principal function of chemical treatment of aluminum is to provide bond for painted finishes. The increase in corrosion resistance is considered a secondary effect. The thickness of chemically produced coatings is given as approximately .00001 in., of standard chromic acid anodized coatings as .00006 in., and of standard sulphuric acid anodized coatings as .0004 in. Chemical treatments can be substituted for chromic or sulphuric acid anodizing only when subsequent primers and paints are applied. For extreme salt atmosphere the combination of chromic acid or sulphuric acid anodizing, zinc chromate primer and at least two coats of aluminum pigmented Bakelite type varnish is considered the best.

C. W. SMITH

Metal Finishes and Finishing Processes

EDWARD ENGEL. *Iron Age* **156**, No. 10, 70 (1945).

This is the first of a series of four articles on this subject. It deals primarily with cleaning and takes up most of the approved technics of obtaining mechanical, physical and chemical cleanliness.

Tables which catalog information of value to metal finishers are (1) spot test identification of metal surfaces, (2) accelerated thickness and porosity test of plated surfaces, (3) salt spray resistance of various thicknesses of electro deposits, (4) electrolytic (galvanic) corrosion factors, (5) atmospheric exposure tests on electro plated steel, (6) comparative frictional properties of metal surfaces, (7) comparisons of pickling, degreasing and cleaning procedures, (8) (a) typical acid pickling and bright-dip treatments, (b) electrolytic pickling, (9) cutting and drawing oils and their removal with solvent, (10) factors in alkali metal cleaning, (11) typical immersion cleaning solutions, (12) typical electrolytic metal cleaning operations.

C. W. SMITH

Metals, Finishes and Finishing Processes

EDWARD ENGEL. *Iron Age* **156**, No. 11, 64 (1945).

The second of a series of four articles. It deals with electrolytic polishing and selection of surface finishes for functional and decorative purposes. Notes on selection of surface finishes and tabulated information are included under the following headings: (13) barrel deburring—polishing — buffing, (14) polishing wheel operation data (typical), (15) operation comparisons of polishing and buffing wheels, (16) typical polishing wheel grade sizes, (17) scratch brush operations for the removal of burrs and scars, (18) physical characteristics of electrodeposited coatings, (19) physical control of plating baths, (20) typical solutions for stripping electrodeposited coatings.

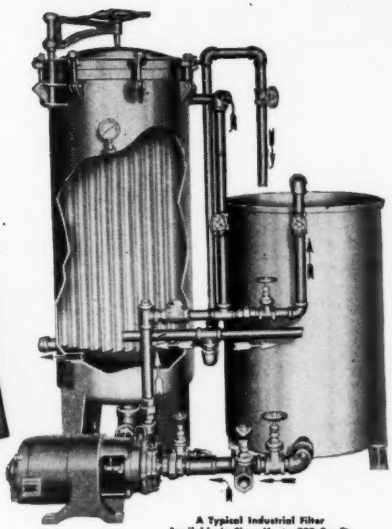
C. W. SMITH

Black Finishes for Steel

H. SILMAN. *J. Electrodepos. Tech. Soc.* **20**, 77-92 (1945).

Black finishes for steel are classified into four main types: (a) oxide, (b) phosphate, (c) deposits of other metals, which are either black or are colored black by chemical means, as black nickel and oxidized copper, (d) organic. The first three types are comprehensively reviewed as to their development, qualities, method of application, etc.

LYMAN B. SPERRY



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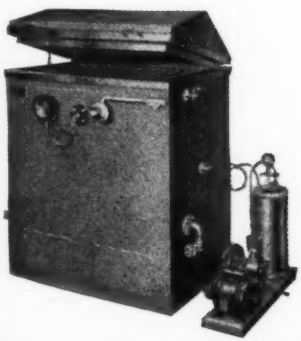

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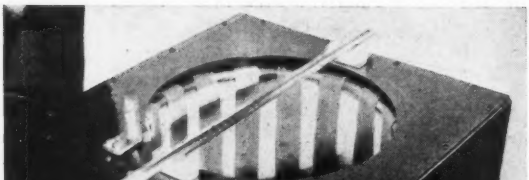

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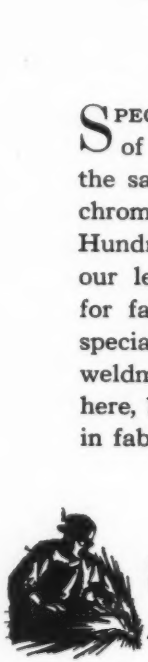

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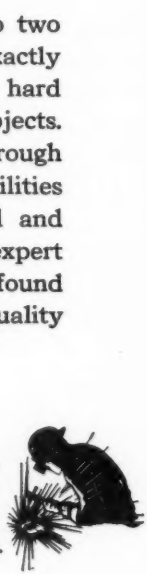
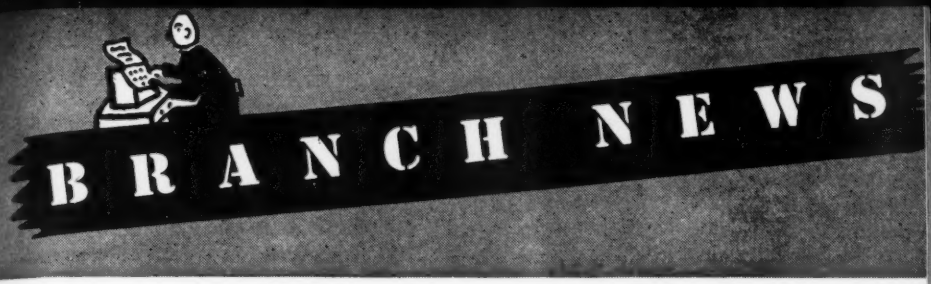


Manufacturers of Welded Fabrications to Specification



BOSTON BRANCH

Boston Branch met on Wednesday, October 3, at the Statler Hotel with Vice-President Callahan in the chair. Since the Branch has not been able to arrange all its meetings on the same night, the next meeting will be on Friday, Nov. 2, at the Statler.

Minutes of the previous meeting were read and approved, communications read and placed on file, bills ordered paid.

The Activity Committee made its report stating that a chemistry class would start on Oct. 8 at the Northeastern University, Boston, Mass. Any member of the Branch may enroll. The fee is $20.00.

One application was read and turned over to the board of managers for approval.

Librarian Chesworth introduced the speaker of the evening, Henry Strow of MacDermid, Inc., Waterbury, Conn. His subject was "Random Observations on Postwar Nickel Plating." It dealt with new developments and improvements, including a fast barrel nickel solution, and also changes in bright nickel solutions. He gave the formula for both the barrel and bright nickel solutions and passed around samples of bright nickel.

Mr. Strow answered all questions put by the members and was given a rising vote of thanks for a very fine talk.

A. W. GARRETT, *Sec'y-Treas.*

COLUMBUS BRANCH

The regular meeting of the Columbus Branch was held at 8:00 P.M. on September 28, 1945 at Battelle Memorial Institute. Following a short business meeting, a paper "Deburring of Metal Parts" was presented by Mr. Roland J. Doucette, Field Manager, Frederick Gumm Chemical Company, Inc. The paper dealt with bulk deburring using stones as a medium in a wet process as compared with older methods using plain sand and water. A discussion and a question and answer session followed the talk.

Mr. E. L. Luaces of the Chemical Development Corporation of Dayton, Ohio gave a short talk on legislation pertaining to licensing of chemists in the State of Ohio. Mr. Neill and Mr. Lavery were appointed delegates to attend a conference concerning this bill at the Fort Hayes Hotel on Oct. 27, 1945.

DAVID S. STOKER, *Secretary*

HARTFORD BRANCH

The first open meeting of the 1945-46 season was held as a joint session with the Hartford Chapter ASM at the Hartford State Trade School. Dinner was served at 6:30 P.M. in the dining room and the educational session was held in the main auditorium at 8:00.

Technical Chairman David J. O'Neill introduced the speaker of the evening, Alexander L. Field, Director of Research, Rustless Iron and Steel Corp., Baltimore, Md., whose subject was "Electropolishing of Stainless Steel." Mr. Field's fine talk covered the history of electropolishing in general and stainless steel in particular, as well as the details of his company's process of electropolishing. Stainless steel is electropolished anodically in a bath consisting of sulfuric and citric acid and water. The temperature is maintained at 90 to 95°C and no spray is evidenced at this temperature thereby eliminating the necessity for exhausting fumes. After the completion of his presentation Mr. Field demonstrated the process in a small pilot setup. Samples and photographs were passed among the audience to demonstrate what could be done with electropolishing.

The 130 members and guests of the ASM-AES accorded Mr. Field a rising vote of thanks.

F. W. SMITH, *Secretary*

SPRINGFIELD BRANCH

The September meeting was held at the Hotel Charles, Springfield, Mass., on September 24, 1945. The meeting was called to order at 8:15 P.M. by former President Colin Hastie.

The following officers for the coming year were then installed by Past President George B. Hogaboom: President, Arthur Copp; 1st Vice-President, Frederick W. Sheehan; 2nd Vice-President, Chester Klimek; Sec'y-Treas., P. F. Lyman; Librarian, Frank J. Clark; Board of Managers: T. J. Murray, Norman Plant and Harold Narcus.

The minutes of the May meeting were read and approved.

Librarian Frank Clark then introduced Mr. George B. Hogaboom of New Britain, Conn., who conducted an "Information Please" program. This he prefaced by a short talk reminding us that there are still many factors involved in electroplating about which the plater is not fully informed.

Among the subjects touched upon in the question and answer period were: Proper method of cleaning copper alloys containing silicon and aluminum; Fluoborate vs. stannate tin plating solutions; Effect of decomposition potentials on the character of deposited metal; Factors governing the use of high current densities; Tank voltage as related to anode-to-cathode distance.

Many of the members and guests participated in the discussion and a very stimulating evening was enjoyed by all.

PAUL F. LYMAN, *Sec'y-Treas.*

WATERBURY BRANCH

Waterbury Branch held its first meeting of the season Friday, September 14th, in the Colonial Room at the Hotel Elton. Following the practice of previous years, dinner was served at 6:30 P.M. and the meeting was called to order by President Cassell promtply at 8:00 P.M. It was with a great deal of pleasure that we welcomed the members of the Plastics Technical Society, who held their meeting jointly with us.

The application for membership of Frank Colaninno was acted upon and he was voted an active member of the Branch. A letter from the Electrochemical Society was read, inviting our members to attend a one-day meeting of the Electrodeposition Division at Hotel Pennsylvania, New York City, on October 24. A letter was read from Leo Bakinow and Henry Stanco expressing their appreciation of the Branch's gifts to them.

The education program was opened with an article on patents read by Henry Strow. This was followed by a new Army film entitled "Fight for the Sky" which showed very graphically the air war over Germany.

It was with much enjoyment that we listened to a talk by Mr. T. J. Russell of the Westinghouse Electric and Mfg. Co. on the subject "The Origin of the Alphabet." Mr. Russell traced the course of its development from its very earliest beginnings in simple hieroglyphics through the ages to the form in which we know it today. This made a most interesting subject, as was evidenced by the vote of thanks offered to the speaker at the close of the meeting.

After a social gathering with refreshments of beer and sandwiches, the meeting adjourned.

S. L. HENN, *Secretary*

TORONTO BRANCH

Opening the Fall season the September meeting was held on Friday the 14th in the Royal York Hotel. A very promising opening it was in view of the fact that when President James Vaughan called the meeting to order, there were close to one hundred members and visitors present.

After the accumulated business of the past two months had been promptly disposed of by referring it to the Executive Board for its consideration, the President called upon Mr. Art West to introduce the speaker of the evening. Mr. West then introduced Mr. George B. Hogaboom, Sr. who really required no introduction to Toronto members, and who has always been a welcome visitor to this Branch.

Every seat in the room was occupied by an interested audience who paid close attention while Mr. Hogaboom delivered a

ninety-minute discourse on "The Modern Trend in the Electroplating Industry." He particularly semphasized the trend towards plating to specified standards in order that we may produce a better and more uniform product than we have in the past. He drew to our attention the various means that we platers have at our disposal today in the form of testing equipment to aid in attaining and maintaining the desired standard of product. He referred to progress made during, and due to, the war, particularly in the field of tin and silver plating where such high current densities are being used that were scarely thought commercially possible in pre-war days.

At the conclusion of his address, Mr. Hogaboom was given a rising vote of thanks and subsequently was kept busy for some time answering questions.

A sad note was injected into the meeting when John Acheson referred to the passing away of two of our Charter members in the persons of William W. Wells and Walter S. Barrows. Both of these men were the pioneers of Toronto Branch and continued their membership therein for thirty-three years to their hour of departure. In respect for their memory the members of the Branch, in meeting assembled, stood in silence with bowed heads for one minute.

An innovation will be put into effect at the next meeting in the form of an indentification badge, with the member's name printed thereon. The badges are to be located in a case at the entrance and each member is requested to place his badge in his coat buttonhole upon entering and to return it upon leaving.

JOHN ACHESON, *Review Correspondent*

ST. JOSEPH VALLEY BRANCH

The regular monthly business meeting was held at 8:00 P.M., August 8, 1945, at the office of the Branch Secretary. Eight officers of the Branch attended.

The meeting was opened by the President, Mr. John Lockerbie. Minutes of the previous meeting of June 27, 1945, were read and accepted.

Mr. Clifford Crouch, Treasurer, presented a financial statement dating from May 1, 1945 to August 8, 1945.

The application of Mr. Theodore D. Shafer of the Bendix Corporation was acted upon favorably.

Mr. K. Harlan gave a report on a meeting which he attended at the Keland's Engineers of St. Joseph Valley, a group consisting of representatives of a number of educational societies of the St. Joseph Valley area. Its monthly magazine contains reports and activities of these societies.

Mr. K. Harlan was requested by President John Lockerbie to act as editor of our Branch in cooperation with the Keland's Engineers and the news agencies in this area.

Mr. R. D. Wysong, Librarian, presented a list of speakers for the fall and winter meetings.

GEORGE A. BOCK, JR., *Secretary*

ST. JOSEPH VALLEY BRANCH

The first monthly dinner and business meeting was held in the Empire Room of the Hotel Elkhart, Elkhart, Indiana, on September 5, 1945.

Forty-one members and guests attended the dinner meeting at 7:00 P.M., supplemented by about twenty-five who attended the educational session at 8:00 P.M.

The business meeting was called to order by President John Lockerbie. The Secretary read the minutes of the business meeting of August 8, 1945, which were accepted. He then read a list of new applications for membership. This group was voted upon and accepted.

A motion was presented by R. D. Wysong that until January 1, 1946, all meetings of the Branch be held in the Empire Room, Hotel Elkhart. This motion was voted upon and carried.

A report was made by the Librarian on the proposed program for the coming year, together with guest speakers for each meeting.

The Librarian, Mr. Wysong, presented the guest speaker for the evening, Mr. W. Morrison of the New York office of the Illinois Water Treatment Company, who gave a paper on the de-ionization of water, which he had presented at the National Convention and for which he had received an award. The paper covered new methods of water treatment which produce water of a purity about equal to that of distilled water. Mr. Morrison outlined on

the blackboard the older methods of deionization and compared them with the advanced methods developed by his company. Following his address, he conducted a short question and answer period covering the subject.

GEORGE A. BOCK, JR., *Secretary*

BALTIMORE-WASHINGTON BRANCH

The Baltimore-Washington Branch held its October meeting on Tuesday, October 2, at the Engineers' Club of Baltimore with thirty- seven members and guests in attendance.

The business session immediately followed the dinner, and was opened by President Huston who introduced the guests present. Reports were made by the committees on: 1. Affiliation with the Engineers Club of Baltimore, 2. Compilation of Branch Historical Records, and 3. The Research Fund.

Three new members were elected, namely William Robert Barnes, John Kreml, and David Weiss. The secretary was instructed to obtain additional information as to Mr. Sweglar's desires concerning his membership application. Four members were suspended for non-payment of dues.

A suggestion was made that registered letters be sent to delinquent members notifying them of action to be taken prior to the meeting at which suspension is to be announced.

The secretary's salary was raised from $20.00 to $50.00 per annum.

Walter Olson, taking over the chair, introduced as the first speaker Mr. G. W. Grupp, Washington Correspondent for *Metal Finishing* and other journals. Mr. Grupp's talk dealt with "experiences" in general, and his "South Pacific Trip During the War Period" in particular. It was both interesting and informative.

Fred Pierdon then introduced the second speaker of the evening, Mr. Robert F. Handley, Supervisor of Apprentice Training Service for this area. Mr. Handley's talk dealt with the functions of the Apprentice Training Service and its relation to electroplating. Both speakers were given a rising vote of thanks.

Before adjourning, Walter Olson expressed the feelings of the entire Branch regarding the news that it is likely to lose the services of its President because of change in his residence. The major portion of the expanded activity of the Branch during the last two years was attributed to Ken Huston's energetic efforts.

ALBERT G. TAYLOR, *Sec'y-Treas.*

BRIDGEPORT BRANCH

The regular monthly meeting was held Friday, September 7, 1945 at the Hotel Barnum. President H. C. Braun opened the meeting with 36 members and guests present.

William Ehrencrona, Chairman of the Outing Committee, reported that an outing would be held on Saturday, September 29, at Eichners Grove, Trumbull, Conn.

The Sick Committee reported that C. C. Helmle and Edward Charleson were sick, but later reports have both of these members well on the way to complete recovery from their illnesses.

F. B. Gotthardt, Chairman of the Membership Committee, reported that three men are to be elected to membership. These were elected later in the evening. Progress is being made in finding applicants.

The Publicity Committee reported that the film and sound projector is available to any member of our Branch.

R. J. O'Connor, 2nd Supreme Vice-President and Delegate to the National Convention held in Pittsburgh, Pennsylvania, June 18, 1945, submitted a report of the meeting. It was read by Ray Kwasnik.

A letter from Kenneth M. Huston, Exhibits Chairman, was read, pertaining to Branch Exhibits at the National Convention in Pittsburgh, in June, 1946. President H. C. Braun appointed the following to the Exhibit Committee to organize the participation of this Branch: Frank Kalafus — Chairman, Arthur R. McNeil and Raymond Kwasnik.

A letter from Edward Loeffel now in the Armed Forces in the South Pacific was read. He is getting along fine but misses the good old U.S.A. He hopes to be back soon and will endeavor to catch up with the progress made in electroplating and metal finishing during the past three years.

JOSEPH G. STERLING, *Sec'y-Treas.*

CHICAGO BRANCH

The Chicago Branch held the regular monthly meeting at the Hamilton Hotel on Friday, October 12, 1945.

President Paul Krause called the meeting to order at 8:00 P.M. with all officers present.

Mr. Frank Savage reported that the Research program was progressing and that there would be four new projects in operation shortly.

Mr. C. Kelly asked each member of the Branch to bring in a new member from his shop.

Mr. R. J. Hazucha reported that the Banquet would be held at the Palmer House on January 19, 1946, with the finest floor show in the city.

Mr. C. W. Carter reported that the Educational Session would be a Symposium on Nickel Plating. It will be held prior to the Annual Banquet in the Club Room of the Palmer House on Saturday afternoon, January 19, 1946.

Mr. A. George, member of Chicago Branch and Manager of the Chicago Office of the Exelon Company, spoke on "Abrasives for Polishing before Plating." The talk was illustrated with slides. Mr. George was given a rising vote of thanks.

There were 88 in attendance and the meeting adjourned at 10:00 P.M.

M. H. LONGFIELD, *Secretary*

JACKSON-LANSING BRANCH

Our first meeting for the season was a dinner meeting at the Hayes Hotel, Jackson, Mich., September 11, 1945. The speaker was from U. S. Stoneware Co., Akron, Ohio, the topic, "Protective Coatings." Only a very small crowd of 36 was present, but the dinner was good, the speaker excellent and the topic very interesting. The discussion following the talk was stimulating to every one.

Our second meeting, October 9, 1945, was also a dinner meeting, this time at the Home Dairy Building, Lansing, Mich. The speaker was Dr. A. E. Chester of the Promat Division who spoke on "A.C. Current and Plating Procedures." Two educational movies were shown. The program was appreciated by the seventy-five members and guests in attendance.

Mr. C. A. Cambell of Solventol Chemical Products Company will speak on "Cleaner Types and their Uses" on November 13 at Hotel Hayes, Jackson, and Dr. D. A. Cotton of Delco Remy Division, General Motors Corporation on "Hard Chromium" on December 11, when a joint meeting will be held with the Lansing Chapter of the American Chemical Society at Michigan State College.

R. E. BROWN, *Sec'y.-Treas.*

NEWARK BRANCH

Meeting on September 21, 1945, President Louis Donroe opened the session at 8:45 P.M. with 38 members present, among them many new members who attended with vigorous anticipation to acquaint themselves with the Educational Policy of the Newark Branch.

Letters from Mr. Ray O'Connor our Supreme 2nd Vice-President making an appeal for membership was in turn referred to our Branch Membership Chairman, Mr. John DeVries, who promised to co-operate earnestly.

A request for exhibits by Kenneth M. Huston, 1946 Convention Exhibit Chairman, was supported and President Louis Donroe appointed William Bruhns as Branch Exhibit Chairman.

The Electrochemical Society announcement of the October 24th meeting featuring the Electrodeposition Division was read. Many of the Branch members will attend.

The financial report for the period June 1, 1944 to June 1, 1945, was read and accepted. Horace Smith, as usual, made the report in his well liked manner. Nice fellow, Horace, however, his record attendance of regular meetings is slipping.

Owing to the absence of our Librarian, Howard Cobb, who was compelled to do some last minute work in connection with our new Year Book, President Donroe appointed Zachary Irenas to act as Librarian. Mr. Irenas gave a very interesting talk describing the sequences of operations used in cleaning, drying and plating at the General Instrument Company's plant in Elizabeth, N. J., of which he is the Supervisor. The talk produced a lively discussion, thanks to Mr. Irenas. As a co-feature Louis Donroe conducted a 30-minute quiz

program with questions of varied types that received much attention. Meeting adjourned 10:45 P.M.

PAUL A. OLDAM, *Sec'y. Pro-tem*

TOLEDO BRANCH

The regular meeting was held on Thursday, September 6, at the office of the Victor Miner Co., Toledo, Ohio.

The meeting was called to order by President Allison at 8:45 P.M.

Mr. Gieger, Educational Chairman, reported that B. F. Lewis of the Northwest Chemical Co. would be our next speaker.

It was suggested that Mr. Gieger attempt to get speakers on bright nickel and on analytical work in the near future.

Mr. E. C. Friedl of the Du Pont Co. gave a very informative and interesting talk on "High Speed Copper Plating."

It was decided to hold the October meeting at Victor Miner's place. President Allison will make necessary arrangements for a lunch after the meeting.

Meeting was adjourned at 10:30 P.M.

GASTON GERGEMAN, *Secretary*

TWIN CITY BRANCH

The Twin City Branch held its monthly meeting on October 8th, 1945 at 6:30 P.M. at the Covered Wagon Cafe in Minneapolis with thirty-four members present. Following the dinner, President Paul Felt introduced our guests: Dr. Walter Meyer of Enthone Company, Mr. Tom Davey of the Chicago Branch, Mr. James A. Murphy of the Detroit Branch, and Mr. Victor Soderberg of the Stolle Corporation, Cleveland, Ohio. The members then welcomed a new member, Mr. Fred J. Kaim of Superior Plating and Rustproofing Company, Minneapolis.

The Secretary gave the final report of the First Annual Party which was held last June. A net profit of $71.74 resulted from this successful get-together.

President Felt introduced Dr. Meyer who spoke on "The Structure and Adhesion of Electrodeposited Coatings." Dr. Meyer's talk was both interesting and informative and upon the conclusion of his presentation, he was given a vote of thanks from the members.

ROBERT L. BUCKLEY, *Sec'y-Treas.*

PHILADELPHIA BRANCH

Philadelphia Branch held its regular September meeting at the Broadwood Hotel, Broad and Wood Streets, Philadelphia, Pa. with a very enjoyable dinner beforehand. All officers, except two members of the Board of Managers, were present.

Following the dinner, President Zurbach turned the gavel over to Librarian Hirsch, who introduced the speaker of the evening, Mr. A. E. Carlson of the General Chemical Co., whose subject was "High Speed Zinc Electroplating." The well delivered talk dealt with the new zinc fluoborate solution, its throwing power and high current density range. Many questions were intelligently presented and answered. Mr. Carlson received a rising vote of thanks.

Dr. A. K. Graham, Executive Secretary, was requested to speak. He reported on the activities and growth of the Society and outlined the Research Committee's active projects. He predicted that about seven projects should soon be in operation and he described methods by which they are started.

The application of Frank P. King, active, was referred to the Board of Managers. The resignation of Bryce Redman, associate, was accepted. The death of Ernest Ohl, active, was noted. William H. McCall, Jr. is serving with the U. S. Navy.

Several communications were read and acted upon.

Assistant Librarian Heiman was asked to inquire about a subscription to Metal Industry of London, England.

The meeting closed with a session around a "vat of suds."

PAUL MENTZER, SR., *Secretary*

DETROIT BRANCH

Nine new members this month and 154 present at the regular October meeting!

W. M. Phillips, Head of the Electrochemistry Department of General Motors' Research Division, praised the platers for their wonderful war accomplishments under great difficulties. Now, we have another kind of job. Competition will set in, specifications are more severe, and there will still be shortages without priorities protection. Thickness of copper and nickel has changed from .001" of 20 years ago

to a present requirement of .003" of combined copper, nickel, and chrome on some parts. There are stiffer specifications for cadmium and zinc. Some bolts and nuts require .0005". Platers must reduce the cost of plating by reducing wheel work in buffing and polishing and by demanding better base metals. The next five years should show the greatest advance in plating; and the improvements will not cost the customer more. (Editor's Note: Mr. Phillips' talk and the discussion which followed, will be published in an early issue of the REVIEW.)

At the next meeting on November 2, Myron Diggin will discuss the "Purification of Plating Baths."

On December 8, the Detroit Branch will hold its annual Educational Session and Party at the Hotel Statler. We expect to equal the pre-war parties and, from present plans, excell them. "Boss" Kettering will start at 2 o'clock with an inspiring discussion on "Looking Into the Future." Dr. Walter Meyer will give a paper on "Finishing of Aluminum." Carl Stockton, of Standard Steel Spring Company will supervise a discussion led by a charming young lady who conducted an original research project. This interesting and unusual paper will take us into a venturesome place in the automobile industry.

Walter Pinner will have 8 to 10 minutes to tell us what has been happening since he became President. Carl Heussner, Chairman of A.E.S. Research Committee, will bring us up-to-date on the seven research projects that are under way.

Following the Educational Session is the dinner and dance. George Nankervis, who is chairman of an able committee, has promised steaks of pre-war quality, the best stage show that Detroit can produce, a beautiful favor for each of the ladies, and dancing until 2:00 Sunday morning. Already the ticket sales indicate that we could sell far more than the 800 tickets available.

We have been promised that Dr. A. Kenneth Graham will be the Honorary Chairman.

GEORGE A. PILLSBURY, *Publicity Director*

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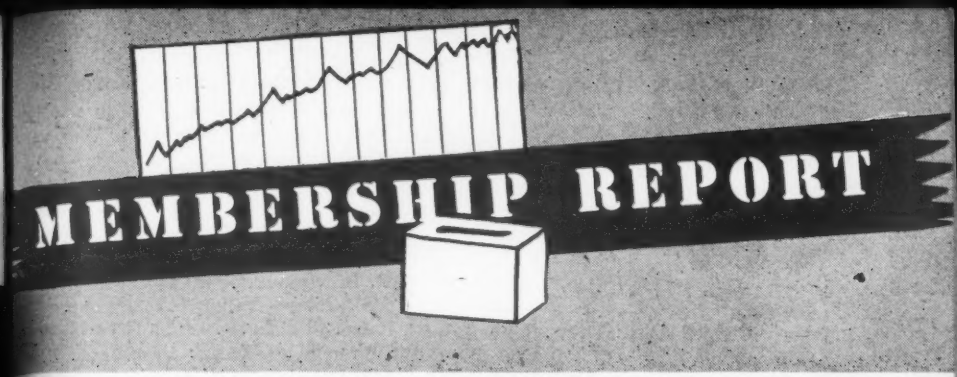

RAYMOND J. O'CONNOR

Chairman, Membership Committee

ELECTIONS

New York Branch

Louis Weisberg, 71 W. 45th St., New York, N. Y.

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MEMBERSHIP CHART

BRANCH	May 1945	Change in Membership	Percent Change
FIRST GROUP			
PHILADELPHIA	154	+10½	+ 6.8
NEWARK	213	+12	+ 5.6
BRIDGEPORT	118	+ 6	+ 5.1
CLEVELAND	143	+ 7	+ 4.9
CHICAGO	357	+15½	+ 4.3
NEW YORK	191	+ 6½	+ 3.4
LOS ANGELES	151	+ 5	+ 3.3
WATERBURY	122	+ 3½	+ 2.9
DETROIT	390	+10½	+ 2.7
BOSTON	157	+ 2½	+ 1.6
GRAND RAPIDS	121	+ 1½	+ 1.2
INDIANAPOLIS	112	+ 1	+ 0.9
BALTIMORE-WASH.	122	+ ½	+ 0.4
ST. LOUIS	116	—	—
TORONTO	119	— 2	— 1.7
HARTFORD	126	— 6	— 4.8
SECOND GROUP			
PROV.-ATTLEBORO	101	+ 6½	+ 6.4
ROCHESTER	90	+ 4½	+ 5.0
PITTSBURGH	80	+ 2½	+ 3.1
BUFFALO	89	+ 1	+ 1.1
MILWAUKEE	107	— ½	— 0.5
NEW HAVEN	106	— ½	— 0.5
DAYTON	109	— 6	— 5.5
THIRD GROUP			
ROCKFORD	23	+15	+65.2
SYDNEY	51	+17	+33.4
TWIN CITY	52	+13½	+26.0
SAN FRANCISCO	55	+ 9½	+17.3
TOLEDO	54	+ 8	+14.8
SYRACUSE	57	+ 5	+ 8.8
JACKSON-LANSING	62	+ 3	+ 4.8
LANCASTER	39	+ 1½	+ 3.8
SPRINGFIELD	73	+ ½	+ 0.7
CINCINNATI	57	—	—
MONTREAL	54	— 1	— 1.9

Membership May 1, 1945 = 3972
Membership Nov. 1, 1945 = 4172

Gain in Membership = 200
Per Cent of Gain = 5.0

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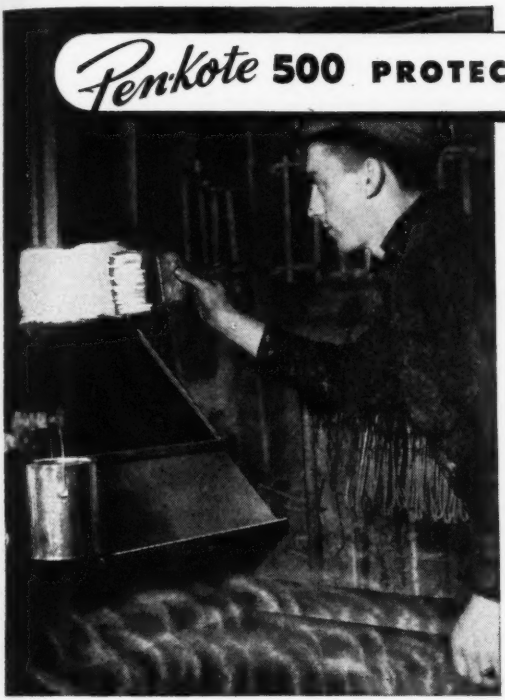

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BOSTON meets first Thursday each month at Hotel Statler, Boston, Mass. Secretary, A. W. Garrett, 35 Rosemont St., Dorchester, Mass.

BRIDGEPORT meets first and third Friday of each month at Barnum Hotel. Secretary-Treasurer, Joseph G. Sterling, 134 Colony St., Bridgeport 8, Conn.

BUFFALO meets second Friday of each month at Hotel Statler, Buffalo, N. Y. Secretary, J. A. Kushner, 316 Winslow Ave., Buffalo, N. Y.

CHICAGO meets second Friday of each month at 8 p.m., Hamilton Hotel, 18 S. Dearborn St. Secretary, M. H. Longfield, 1528 South 61 St., Cicero 50, Ill.

CINCINNATI meets on fourth Thursday of each month at 8 p.m., at the Engineering Society Headquarters, Mc Millan St. and Woodburn Avenue, Cincinnati, Ohio. Secretary-Treasurer, Elliott W. Horning, 2425 Kenilworth Ave., Norwood 12, Ohio.

CLEVELAND meets first Saturday of each month at Cleveland Hotel. Secretary-Treasurer, Harvey P. Heil, 12901 Elmwood Ave., Cleveland 11, Ohio.

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GRAND RAPIDS meets second Friday of each month, 7:30 p.m., at the Rowe Hotel. Secretary, R. Perkins, 916 Fairmount St., S.E., Grand Rapids 6, Mich.

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(*Continued on next page*)

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(*Continued from preceding page*)

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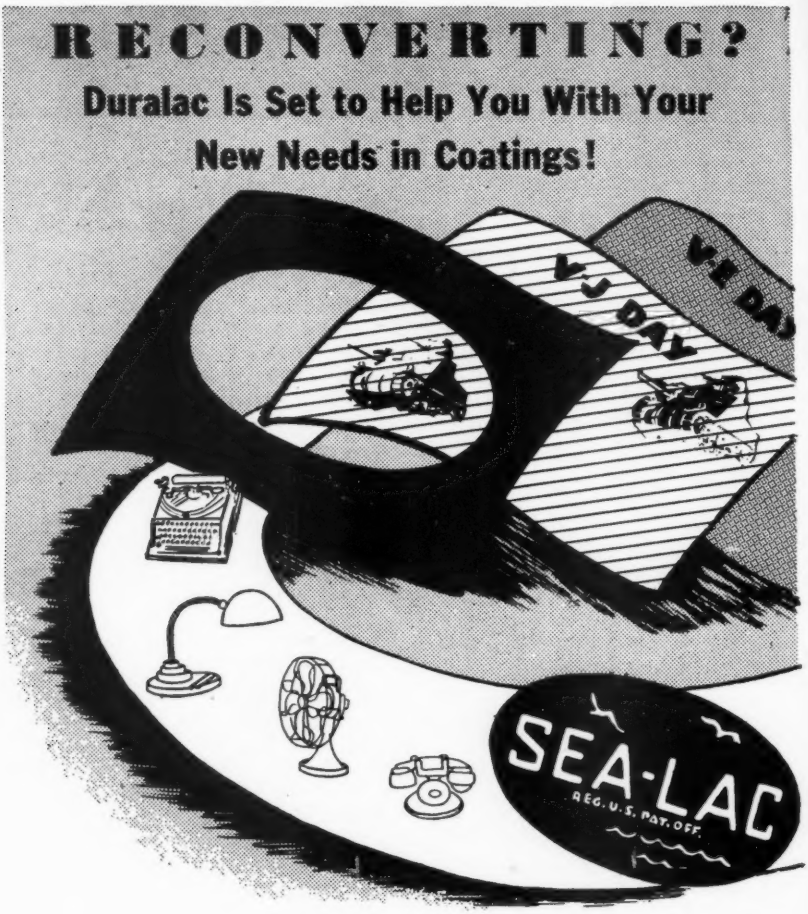

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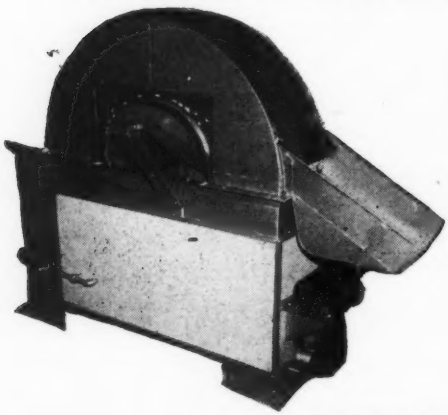

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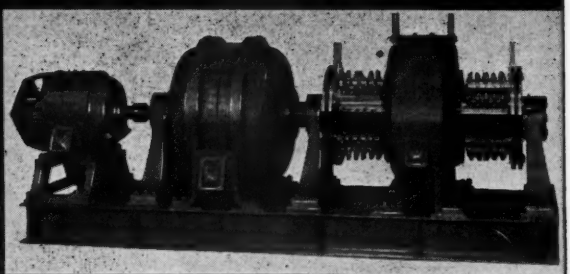

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